COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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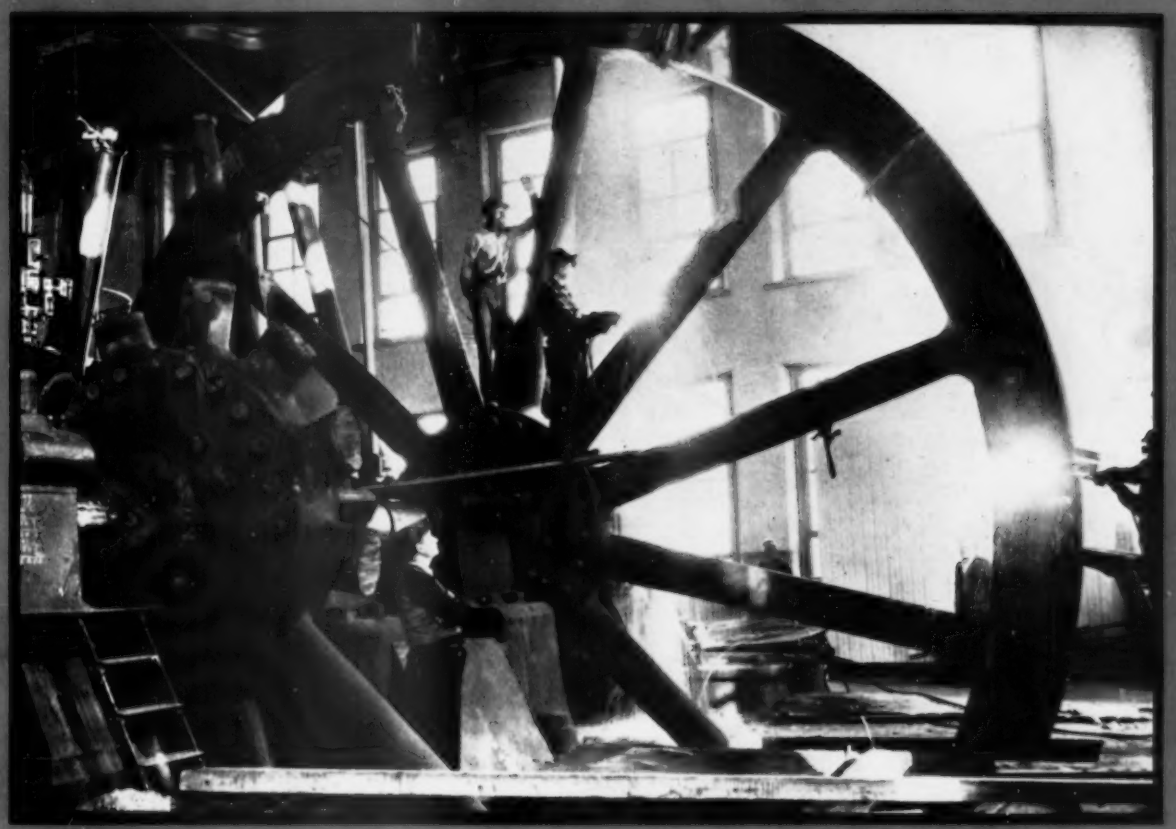


Old engine flywheels make scrap for defense

Mechanical Features of Edge Moor Power Station

Television in Steam Power Plants

ASME Semi-Annual Meeting

One VU can start a family

With fuel costing what it does today, it is more important than ever before to select a boiler that will assure the most efficient performance possible. That is why so many companies who watch steam costs closely have acquired sizeable families of Vertical Unit Boilers. For example:

A Chemical Company ordered two VU Boilers in 1939. In 1946 five more were ordered for three of their other plants. In 1949 another was ordered for one of these same plants, and in 1950 two more units for a fifth plant. In 1951 three more units were ordered for still another plant — thirteen units for six plants in twelve years!

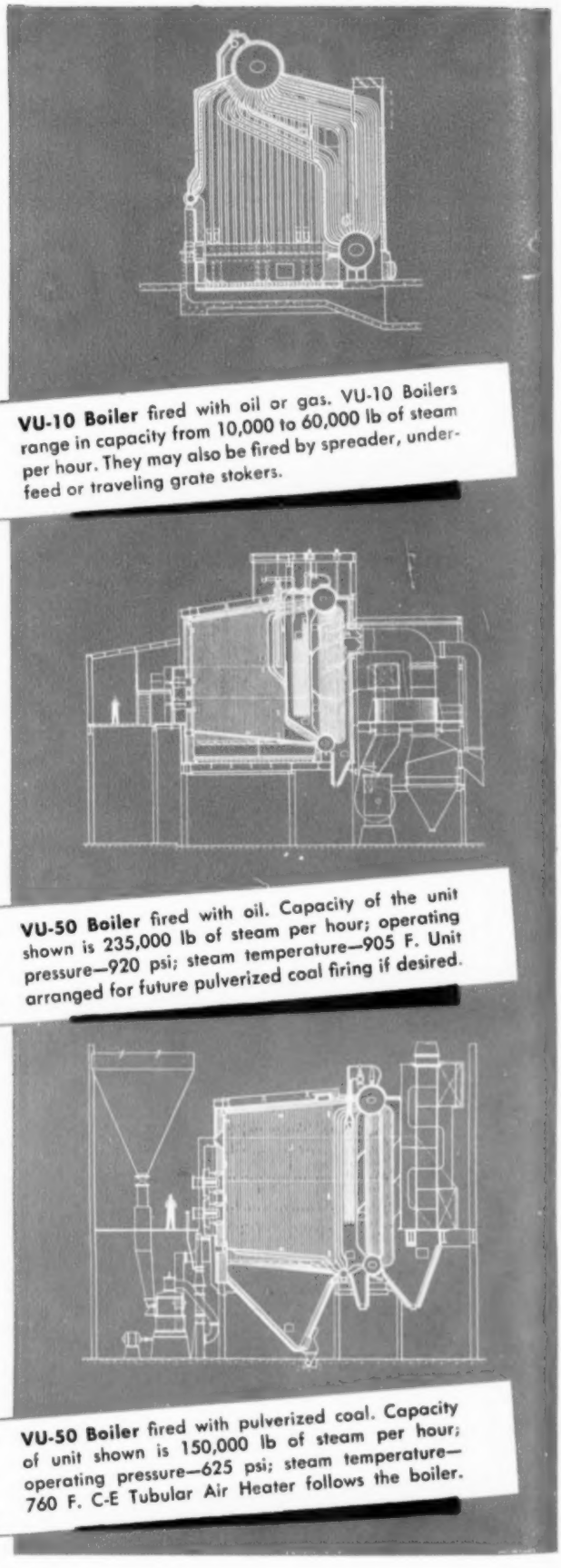
An Electric Utility Company ordered its first VU in 1941. In 1945 it ordered a second VU for a different plant. For another of its plants one unit was installed in 1946 and two more in 1947. In 1949 a VU was installed in a fourth plant, and in 1950 one was installed in a fifth plant. A total of seven boilers in five different plants.

A Sugar Company ordered two VU Boilers for one of its plants before the war. In 1946 it ordered a VU for a second plant. And in 1950 another VU was installed in this same plant.

A Steel Company now has a total of fourteen VU Boilers in four different plants. Starting with an installation of two units in the early thirties, it has reordered six times. The most recent installation of two units at one of its plants was completed in 1948.

* * *

This is just a small sample of the hundreds of companies that have ordered and *reordered* the VU Unit. They have found *through their own experience* that the advanced design, sound construction and consistent reliability of the VU Unit mean *lower steam costs*. Once you have a VU in service you soon know why it is that so often *one* VU starts a family. B-494A



VU-10 Boiler fired with oil or gas. VU-10 Boilers range in capacity from 10,000 to 60,000 lb of steam per hour. They may also be fired by spreader, underfeed or traveling grate stokers.

VU-50 Boiler fired with oil. Capacity of the unit shown is 235,000 lb of steam per hour; operating pressure—920 psi; steam temperature—905 F. Unit arranged for future pulverized coal firing if desired.

VU-50 Boiler fired with pulverized coal. Capacity of unit shown is 150,000 lb of steam per hour; operating pressure—625 psi; steam temperature—760 F. C-E Tubular Air Heater follows the boiler.

C-E

COMBUSTION ENGINEERING — SUPERHEATER, INC.

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200 Madison Avenue • New York 16, N. Y.

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 23 **No. 1**

July 1951

Feature Articles

Mechanical Features of Edge Moor Power Station 32

ASME Semi-Annual Meeting Held in Toronto, Canada
Ultrasonic Field Inspection; Spreader Stoker Tests; Symposium on Centralized Control and Small Gages; Model Tests of Piping; Marine Engineering; Turbine Supervisory Instruments; Coal-Burning Gas Turbine 37

Developments in Use of Television in Steam Power Stations ..... *by L. M. Exley* 43

Electric Power Survey 47

Developments in Marine Boiler Design ..... *by S. F. Mumford* 50

INCO Holds Corrosion Conference 57

Status of Atomic Power 59

Editorials

Low Scrap Supply Threatens Defense Program 31

Television for Boiler Operation 31

Financial Support for Higher Education 31

Departments

Facts and Figures 42

Catalogs and Bulletins 62

Advertisers in This Issue 63

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COPES *Applied to Hydraulic Couplings*

GIVES PRECISE FEED AND LEVEL CONTROL

at PLANT YATES *of* GEORGIA POWER COMPANY

Remarkably close feed-flow and water-level control is being demonstrated daily by the COPES Balanced Flow Control at Plant Yates of Georgia Power Company, Newnan, Georgia. Units 1 and 2 went into service late in 1950.

Each unit includes a 3-drum, dry-bottom, radiant-type Combustion Engineering-Superheater boiler designed for a maximum continuous rating of 975,000 pounds per hour. Loads have been carried as high as 1,050,000—as low as 250,000—pounds per hour.

The COPES Control, applied through the hydraulic couplings of the feed pumps, matches feed flow almost perfectly to steam flow, and stabilizes water level within plus-or-minus one inch. Independent of meters and other controls, it can remain on full-automatic when they must be out of service for any reason. Duplicating COPES Control is on order for Unit 3, scheduled to start operation next winter. For complete data on COPES Balanced Flow at this utility write for Bulletin No. 489.

NORTHERN EQUIPMENT DIVISION

Continental Foundry & Machine Company

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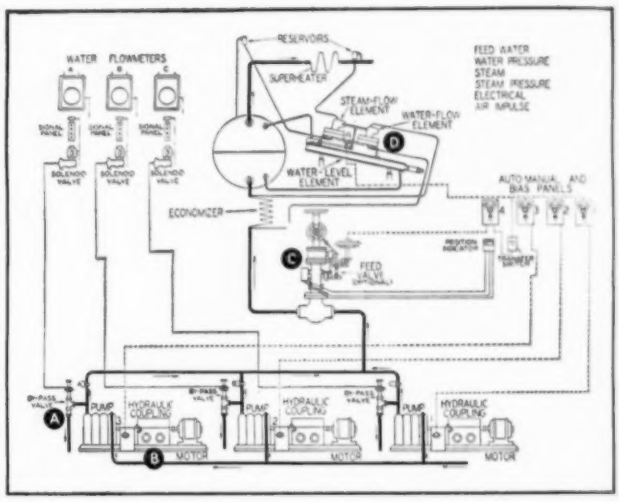
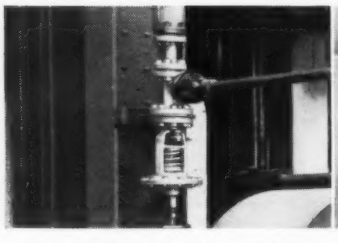


Schematic shows COPES Balanced Flow Control installed for each boiler at Plant Yates. Responsive to three influences—steam flow, feed flow and water level—COPES applies air impulses to position individual controller for the hydraulic coupling of each motor driven pump. Two pumps are normally paralleled, with third on standby, but any pump can be cut in or out by pushing the button to start or stop its motor.

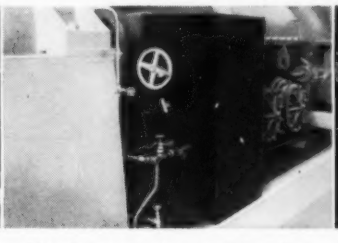
Feed valve is normally wide open, but can be cut into automatic service at any time.

COPES Minimum Flow Control protects the pumps against overheating on light loads.

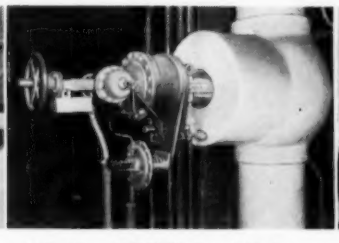
***Headquarters for* Feed Water Regulators • Pump Governors • Differential Valves • Level Controls • Hi-Low Alarms • Reducing Valves • Desuperheaters**



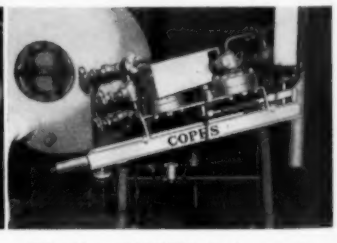
(A) COPES Recirculating Valve used with the Minimum Flow Control System to protect the pumps on light loads.



(B) Air impulses from the COPES Balanced Flow Control actuate this controller on the hydraulic coupling to control the speed of each boiler feed pump.



(C) The COPES Feed Valve, installed in a vertical line, is normally wide open but may quickly be placed on fully-automatic, if and when this is desired.



(D) The COPES Balanced Flow Thermostat has steam-flow and water-level elements mounted rigidly on the frame of the water-level element. It is rugged.

COPES **BOILER FEED WATER REGULATION**

Editorials

Television for Boiler Operation

It has been a long step, over the last thirty-five or forty years, from the few simple instruments then employed to assist in manual operation of boilers to the present formidable array now seen on boiler boards, including automatic combustion control. One might infer that nothing further is needed, save an occasional peep into the furnace to satisfy the experienced eye of the operator that all is well. However, with pulverized coal, and to some extent with oil or gas, much can happen between such peeps that can cause considerable trouble, particularly when lighting off or through loss of ignition; hence the application of television, permitting continuous remote observation by the control-room operator of what goes on in the furnace.

Pioneer development in the application of television to furnace operation has been carried on to a successful conclusion at the Port Jefferson Station of the Long Island Lighting Company, as described by Mr. Exley elsewhere in this issue. With the present marked trend toward centralized control and reduction in operating personnel for new plants, such use of television should appeal strongly to both operators and designers, particularly central station engineers.

Low Scrap Supply Threatens Defense Program

The increase in steel output to date and the expansion in productive capacity now underway are taxing heavily the supply of scrap, even to a critical degree in some instances. Last year over twenty-nine million tons of scrap were purchased by steel plants and foundries; requirements for the current year are placed at thirty-two million; and schedules for next year call for thirty-five million tons. The problem now facing the steel industry is where to acquire this amount, since the supply of heavy steel scrap coming through normal channels is dangerously low.

Scrap, it will be recalled, is essential in the manufacture of steel, because it not only adds to the quality of the steel, but also because it shortens the refining process and conserves both iron ore and coal.

During the last ten years vast quantities of steel went out of the country, the greater part of which was expended as war material and very little of which has found its way back as scrap, due to questions of ownership and problems of handling. Moreover, rising steel production abroad has cut down scrap importation.

Heavy melting steel is more desirable for this purpose than light bundled scrap, and there is no present intention of initiating a household drive, as was done during World War II. One of the principal sources of scrap is the steel industry itself, where a considerable portion of the ingot becomes scrap in the manufacturing and finishing process. Other prolific sources include obsolete railroad equipment, retired ships, condemned structures, automobile graveyards and factories that yield obsolete machines. Power plants, although not a major source, are often able to contribute their share.

In order that the defense program may not suffer from the scrap situation and industrial production have to be greatly curtailed, the National Production Authority, with the cooperation of the American Iron and Steel Institute, has initiated a campaign to stimulate the movement of dormant scrap through normal channels. Both industry and agriculture have been asked to assist and special advertising programs have been prepared. On the part of the regular government, Secretary of Commerce Sawyer has issued an appeal to Federal agencies to aid the NPA in this drive.

It is believed that many power plant yards will be found to contain appreciable quantities of scrap which, if disposed of through regular channels, will make an important contribution to the drive. Let's not put off surveying this potential source.

Financial Support for Higher Education

Privately endowed colleges and universities face many financial problems as a result of continued inflationary trends. Sizable individual contributions toward endowment cannot be counted upon to the extent they have been in the past. In addition the rate of income on endowment has been greatly reduced, one study showing that it is little more than half of what it was twenty years ago. Tuition rates may continue to increase, but unless they are paralleled by many additional scholarships the result will be to limit opportunities to attend these institutions.

In a recent issue of *Collier's*, Alfred P. Sloan, Jr., chairman of the board of General Motors Corp., urged that industry should help support colleges in order to continue raising American standards of living. Decrying the trend to look toward Washington for things that could be provided elsewhere, Mr. Sloan felt that corporate enterprise could aid educational institutions without the latter losing freedom of action, as might be the case under some kinds of government support. The interesting part of his proposal is that liberal-arts institutions deserve support on the basis of long-range public interests. Even though not directly related to production, social sciences and the humanities will, he believes, become increasingly important in the future. This is in line with the trend in engineering education of devoting a greater amount of undergraduate time to these studies.

Future progress is to a large extent dependent upon the training that can be given by institutions of higher education. Private enterprise as one of the beneficiaries of this training may do well to consider how it can provide further assistance to privately endowed schools.

Photo by Willard Stewart, Inc.

Aerial view of Edge Moor Power Station; new Delaware Memorial Bridge in background

Mechanical Features of Edge Moor Power Station

The present installation at Edge Moor Power Station consists of two 60,000/66,000-kw Preferred Standard turbine-generators which with their auxiliaries operate on a closed cycle with five stages of extraction for feedwater heating. Throughout the design of the plant an attempt has been made to insure reliability, and therefore equipment has been selected which has been thoroughly tested in commercial operation. Centralized control has been adopted in order to achieve easier and more simple operation.

EDGE Moor Power Station is the first major steam plant on the electrical system of the Delaware Power & Light Company. It is located on the Delaware River within the city limits of Wilmington.

Planning and preliminary studies for this station began in 1945, and the decision to proceed with construction was made early in 1948, the first of two 60,000-kw units being placed in commercial service on June first of the present year.

Semi-outdoor construction is employed with the economizers, dust collectors, air heaters, flues and stacks outdoors. The outer casings of this equipment have been designed to withstand the weather and the top surfaces have been pitched and arranged for drainage of rain and snow.

The location of the main station structure was chosen on the basis of the most satisfactory soil conditions and adaptability to the basic design. The stacks and boilers are placed adjacent to the Delaware River and the turbine-generators and their switching equipment are set back from the river.

The exterior construction is brick and tile except for the south wall of the building which has temporary insulated aluminum panels in order to provide for future expansion.

Steam Generation

The initial installation contains two 600,000-lb per hr Combustion Engineering-Superheater three-drum radiant-type steam generating units, having fully water-cooled furnaces and dry hopper bottoms with shaded ash-pits. Present plans are to burn bituminous coal and

heavy fuel oil, but the boilers can be adapted to burning natural gas when a suitable and dependable supply becomes available for use.

Design pressure is 1500 psig with operating steam conditions at the superheater outlet of 1300 psig, 950 F. Steam temperature control over a range of 360,000 to 600,000 lb per hr is by tilting tangential burners supplemented by spray-type desuperheaters.

Each unit incorporates a 21,800-sq ft three-stage pendant-type Elesco superheater and a fin-tube, counterflow economizer having a total heating surface of 20,250 sq ft. A Buell mechanical-type dust collector is located between the economizer outlet and the tubular air-preheater inlets.

An unusual feature of the design is incorporated in the air preheaters, of which there are two per unit. They are divided into two sections, one containing two sets of 2-in. steel tubes 30 ft in length with a heating surface of 58,750 sq ft and the other one a set of 3-in. aluminum tubes 15 ft in length with a heating surface of 13,650 sq ft. The induced-draft fans are connected on the suction side to the steel-tube section of the air heater and discharge into the aluminum-tube section. This arrangement was chosen to minimize corrosion problems when operating at low loads. Provision is made to bypass sections of air-heater surface and to recirculate air from the discharge of the heater to the forced-draft-fan inlet. The flues from the air heater to the radial-brick stack have been insulated as a further means of guarding against possible condensation and corrosion of the air heater plates.

Four C-E Raymond bowl mills having a nominal capacity of 15,300 lb per hr (based on a coal of 75 Hardgrove grindability, maximum moisture of 10 per cent) serve each steam generating unit. An exhauster is directly connected to the mills which are driven by 200-hp, 1200-rpm motors. Three mills are capable of handling full load with a Central Pennsylvania bituminous coal of the following analysis.

Moisture, per cent by weight	4.0
Volatile, per cent by weight	25.3
Fixed carbon, per cent by weight	61.3
Ash, per cent by weight	9.4
Sulfur, per cent	2.0
Btu per lb, as-received	13,700
Ash softening temperature, F	2400
Hardgrove grindability	75

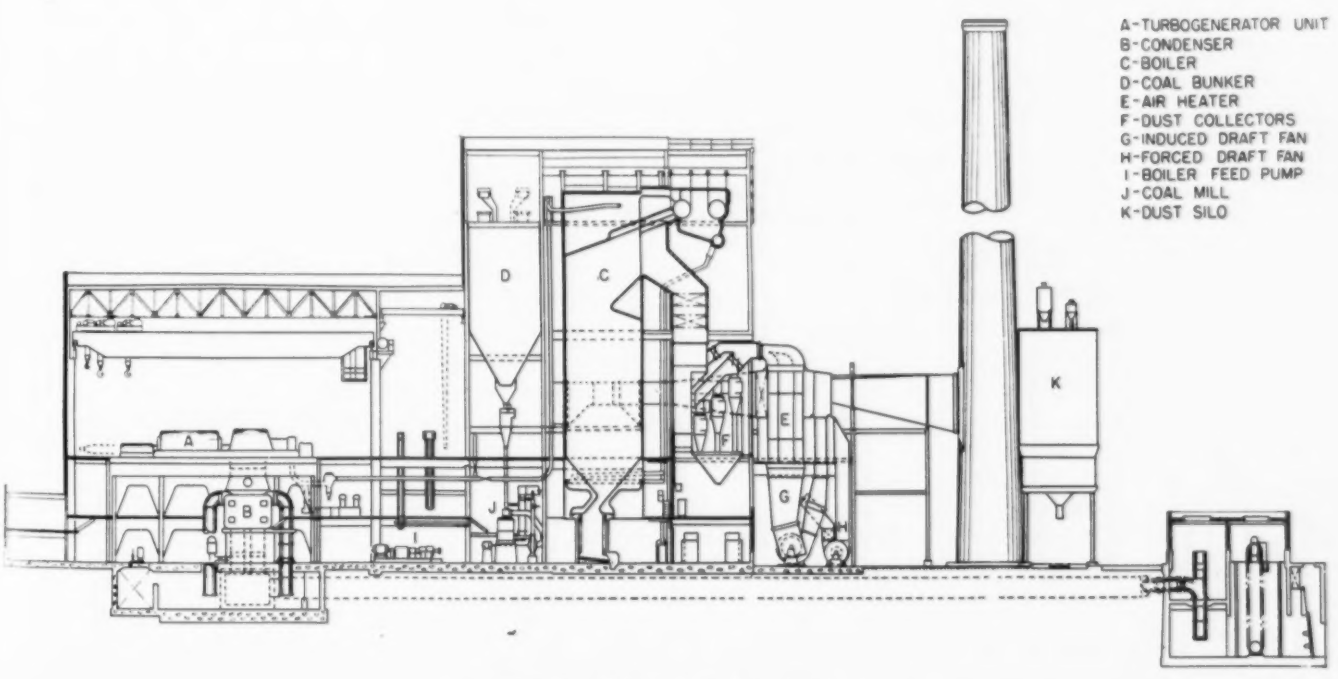
The boilers are completely enclosed in panel-type steel casings which are connected to the ash hoppers without the use of seals. The air heaters and economizers are located out of doors and have double casings.

Soot blowing is by means of the Diamond automatic sequential air-operated, air-blowing system. Where temperatures are over 1500 F, the soot blowers are of the retractable type operated by air motors.

Ash is sluiced from a flooded ash pit by means of an Allen-Sherman-Hoff hydraulic system and pumped to a settling and dewatering basin outside the station. The sluicing system ordinarily operates once a shift. Fly ash from the base of the 220-ft brick stacks and the mechanical dust collectors is carried by an A-S-H Hydrovac automatic dust disposal system to a 300-ton storage silo equipped with two dustless unloaders.

Each steam generating unit has two forced-draft and two induced-draft fans, all of which are located at ground level. To avoid difficulties from freezing of cooling-water lines, the fan bearings are cooled by air which follows the same path as would normally be followed by cooling water. Sun shades are also provided over the bearings.

The forced-draft fans are of Westinghouse-Sturtevant design and have electrically operated inlet-vane control. Each forced-draft fan is rated at 85,000 cfm at 80 F and 12 in. w.g. and drive is by a 1200-rpm, 200-hp constant-speed motor. A connection has been provided from the air-heater outlet to the forced-draft fan inlet for recirculation of hot air in cold weather to avoid freezing at the inlet vanes.



Sectional elevation of station

The induced-draft fans, each of which is rated at 190,000 cfm at 500 F and 14-in. w.g., are also of Westinghouse-Sturtevant design and are driven by 600-hp wound-rotor motors. The speed of these fans is controlled over an 80 per cent range by means of Allis-Chalmers liquid rheostats located inside the building. Although this type of speed control is less common in central stations than hydraulic and magnetic variable-speed couplings, it has been widely used in the steel industry. It consists essentially of an electrolyte bath of sodium carbonate in which fixed and movable electrodes are immersed. The distance between electrodes and volume of electrolyte determines the resistance in the motor secondary circuit, hence the motor speed. The movable electrodes are automatically positioned by the combustion control to provide the required motor and fan speed. The electrolyte is circulated by a pump through a heat exchanger to dissipate the heat generated by the electrical resistance. Provision is made for the motor secondary terminals to be short-circuited and the fan run at constant speed with outlet damper control in the case of failure of the liquid rheostat which by reason of simplicity of parts and assembly can be repaired in a minimum of time. With this type of speed control the losses are about the same as with hydraulic and magnetic couplings. In this installation it has the advantage that controls can be located indoors, while only the motor electrical leads are outdoors.

Turbine-generators

The turbine-generators are General Electric, AIEE-ASME Preferred Standard, 60,000/66,000-kw, 3-phase, 60-cycle condensing units. The turbines are of the tandem-compound, double-exhaust-flow design.

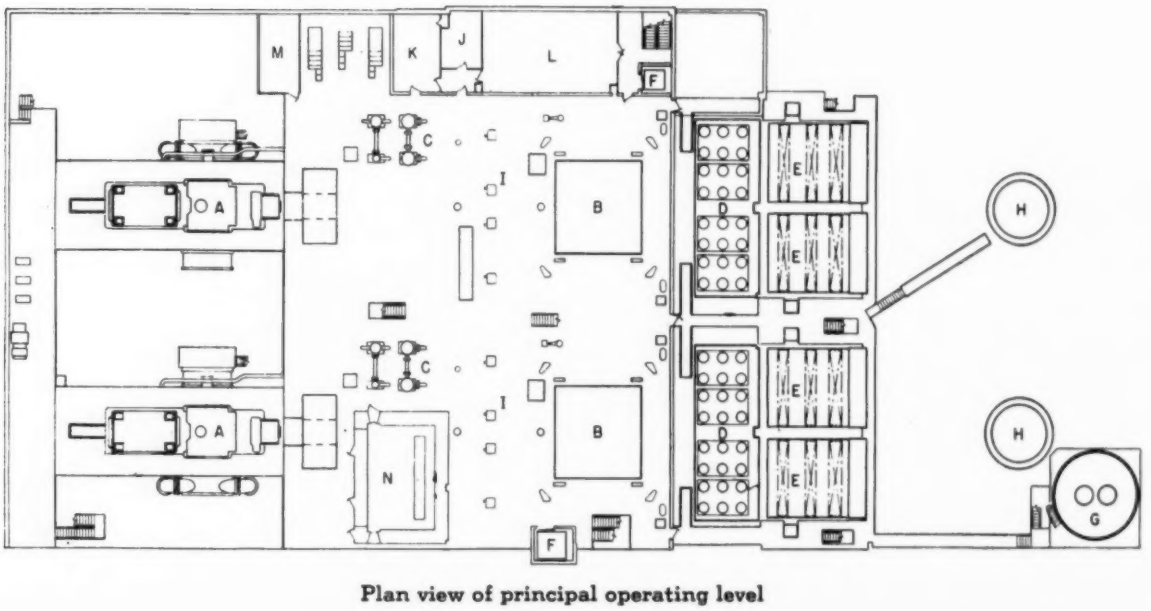
Steam is extracted at five points for feedwater heating. The heaters, which are of the closed U-tube type, are designated as Nos. 1 to 5 in order of increasing extraction pressure. The normal flow of water is from the hotwell and condensate pump through the three low-pressure heaters to the boiler-feed-pump suction. From the boiler feed pumps it passes through the two high-pressure heaters to the economizer.

The heaters are all vertical except No. 1 which is horizontal and located in the neck of the condenser. Drains from the higher-pressure heaters are cascaded down to No. 2 heater and pumped back into the feed line. Those from No. 1 heater are discharged into the condenser. By locating No. 1 heater in the neck of the condenser, extraction piping is simplified and the possibility of air leakage into extraction lines is reduced.

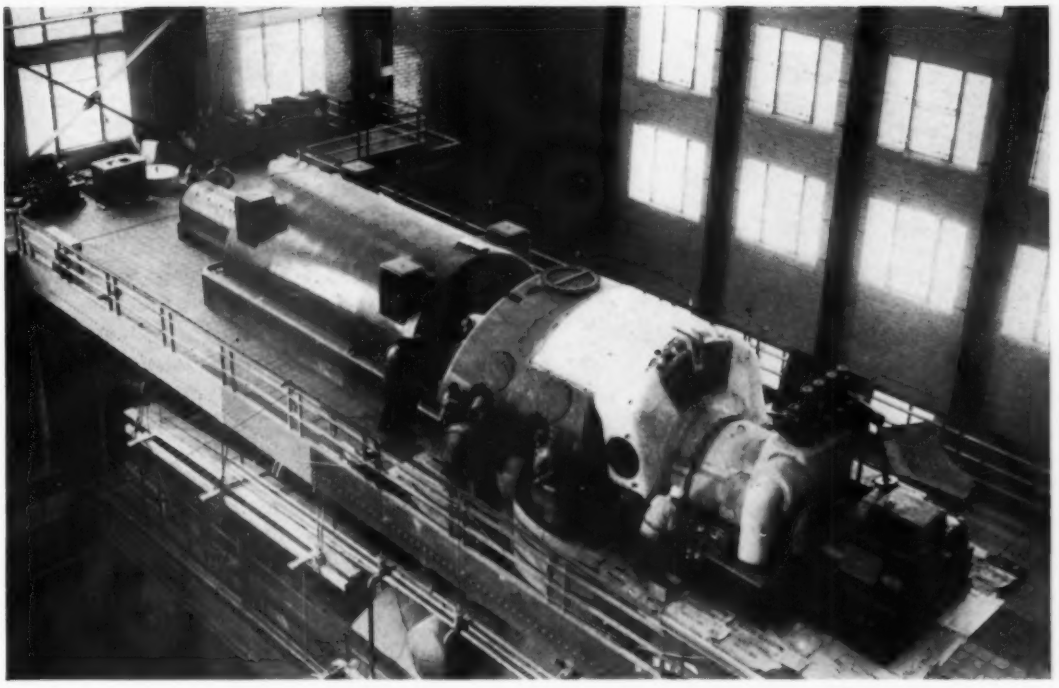
Three barrel-type Worthington boiler feed pumps are provided for each unit, any two of which will carry maximum load. Individual pumps are rated at 750 gpm of 295-F feedwater with a discharge pressure of 1600 psig and are driven by constant-speed motors through American Blower hydraulic couplings. The speed of the pumps operating is determined by a Bailey three-element feedwater level control on the boiler. This method is justified by savings in power compared to that required for a constant-speed drive with a feedwater regulating valve. To take care of an emergency a motor-operated regulating valve is installed and can be used for remote manual control.

A cross-over connection is provided between the primary steam lines of Units 1 and 2, and there is a similar interconnection of the boiler feedwater lines. Normally one steam generating unit serves one turbine-generator, but for the first section of the station it was considered desirable to have provision for either boiler to serve either turbine. Future units will not have a cross-over connection.

A- TURBOGENERATOR UNIT
B- BOILER
C- FEED WATER HEATERS
D- DUST COLLECTORS
E- AIR HEATERS
F- ELEVATORS
G- DUST SILO
H- STACKS
I- COAL FEEDERS
J- CHART STORAGE
K- INSTRUMENT SHOP
L- ASSEMBLY ROOM
M- CHIEF SHIFT OPERATORS OFFICE
N- CONTROL ROOM



Plan view of principal operating level



No. 1 turbine-generator nearing completion of erection

Makeup water is purchased from the Delaware Water Co. and is pumped by two 250-gpm booster pumps to a 10,000-gal water-storage tank. It is then treated in a zeolite softener and passes through a small deaerating heater after which it is pumped to two evaporators, one serving each unit of the present installation. When in operation these evaporators float on the line between heater Nos. 3 and 4, and their output is manually controlled by a valve in the steam line to the coils. The rate of water fed to the evaporator is controlled automatically by the water level in the evaporator shell. The vapors are condensed in the No. 3 heater and enter the cycle with the heater drains.

Steam for station heating is supplied from the evaporators. Condensate from the heating system is returned to the evaporators through the makeup deaerating heater.

Provision has been made for considerable storage of condensate. There is a 100,000-gal tank located outside of the station and two 10,000-gal overhead storage tanks, one for each unit. Each condenser also has a 10,000-gal storage hotwell. At full load the 20,000-gal storage provides a 16-minute supply of water for each unit. With these provisions for storage the operators are allowed considerable flexibility in evaporator operation. Makeup can be drawn from the storage system and the evaporators operated when it is necessary to replenish this supply, or they may be run continuously at low ratings in either or both cycles.

Although evaporator operation is manual, the distribution of condensate in the storage system and its introduction into the cycle is controlled automatically.

It is expected that the system will be operated on very low makeup on the order of one-half to one per cent. By using air-operated soot blowers and motor-driven vacuum pumps on the condensers instead of steam-jet air ejectors, steam losses are kept to a minimum. The only uses for steam, aside from driving the main turbine-generators, are to charge a fireless locomotive used for yard switching and for a turbine-driven auxiliary oil pump in the turbine lubricating system and a turbine-driven fuel oil pump.

The Ingersoll-Rand condensers are of the single-pass, divided water-box design. Each has 40,000 sq ft of surface and requires 72,000 gpm of circulating water when operating at 1.5 in. Hg and rated load. Condenser evacuation is carried out by Kinney mechanical vacuum pumps.

No separate deaerating feedwater heater is incorporated in the cycle. Deaeration is carried out in the condenser which has a two-stage reheating and deaerating hotwell. Steam for the first stage is obtained from the condenser, while that for the second stage is provided from the No. 2 extraction line. Steam admitted from this line is controlled by an automatic valve to maintain a differential of about $^1/_2$-in. Hg between the two stages. Oxygen content of the feedwater is expected to be 0.01 cc per liter or less. Air from the deaerating hotwell is vented to the air-cooler section of the condenser and drawn off by mechanical vacuum pumps.

Circulating Water System

For the first two units a single screen house and pump well are installed. Two Ingersoll-Rand vertical-type pumps discharge through a 66-in. I.D. concrete pipe to each condenser. Gates are provided in the pump well so that the pumps for each unit may be operated separately.

Because of the corrosive condition of Delaware River water, portions of the traveling screens, circulating-water pumps, and intake pipe are lined with a synthetic rubber coating. The impellers and shafts of the circulating-water pumps are made of stainless steel, and the pump casings, of high-nickel iron. The fire, sluice and screen-backwash pumps are similarly constructed. All pumps are remotely controlled from the pump panel located in the station.

Car dumper in operation

From the condensers the circulating water is discharged to a concrete tunnel and to an earth canal which is large enough to serve the ultimate station. To protect against icing a tempering line is run from the discharge of the condensers to the screen well.

Fuel Handling

Basic planning for the coal handling system was predicated on the basis of its operation on a single shift and a five-day week. Coal is received by rail over a siding from the Pennsylvania Railroad, and is unloaded by means of a Link Belt car dumper of sufficient capacity to meet requirements of the ultimate station. A car dumper was chosen because of its relative quietness, ease of operation, and low maintenance. Thawing pits may be considered at a later date for handling frozen coal, but for the present portable flame throwers will be used.

The coal is transported from the point of unloading by a 42-in. belt conveyor to a Bradford breaker. After being crushed it is discharged to a conveyor to the station bunker or into carry-alls to storage. In reclaiming coal from storage carry-alls are also used, depositing the fuel in a reclaiming hopper from which it is transported by the same conveyors to the breaker house and to the bunker. The latter is of the divided type and has sufficient capacity to operate both steam generating units for a period of about $2^1/_2$ days.

Future delivery of coal by barges on the Delaware River has been studied, and provision is made to install unloading equipment and construct another belt conveyor from the river to the breaker house.

All of the coal is crushed before being placed in storage, and the use of carry-alls insures a thoroughly compacted pile with decreased fire hazards. Storage capacity is between 200,000 and 250,000 tons.

A fuel-oil storage tank of 80,000-bbl capacity has been constructed, outside the station, along the Delaware River to permit barge delivery. A separate building houses the fuel oil pumps and heaters, which have sufficient capacity to supply the first two boilers when both are operating at full load.

Centralized Control

A 20 × 30 ft control room contains all controls for the first two units. The room is fully enclosed and its walls are formed by the instrument cubicles, the outer walls of which are insulated to reduce sound transmission.

In starting up equipment it was felt desirable to have separate panels located near the equipment so that the operator could observe operation. The following panels have been installed: boiler panel, turbine panel, and pump and heater panel, which also contains the controls for the circulating water and boiler feed pumps and other station auxiliaries.

After a boiler and turbine have been started up at local panels and the turbine is up to speed, operation is transferred to the central control room where the operator of the central controls synchronizes the generator, puts it on the line and loads it as directed by the load dispatcher.

There are about 300 instruments and controls in the control room for each unit and about 100 more for station auxiliaries. The controls essential for boiler and turbine operation have been arranged in starting-up sequence on the bench board, and the essential instruments which guide operation have been mounted on the panel in front of the bench board within the normal angle of the operator's vision. The instruments are mounted in the same sequence as the controls. Essential generator and electrical controls are located in the center of the bench board on a mimic bus diagram. Other less essential instruments and controls have been located on the panels forming the side and rear walls of the room.

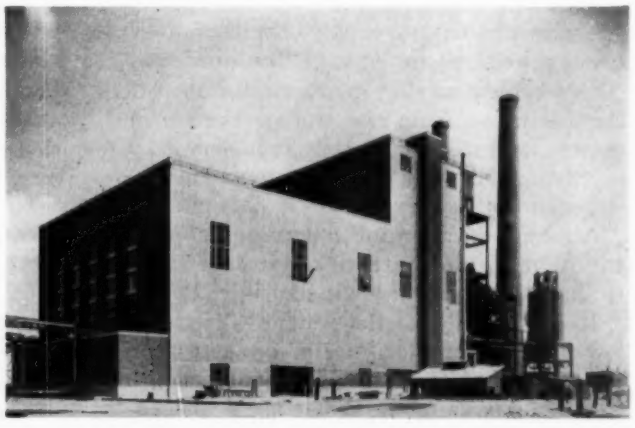
Large indicating instruments and standard indicating recorders have been used on the panel boards so that they may be easily observed by the operator. An internally illuminated alarm panel, with large lettered nameplates, is located in the center of each side wall, where it can easily be read by the operator from his usual position.

As a safety precaution no high-pressure steam or water lines or oil lines are carried into the control room. Electronic or air transmission has been used from indicating transmitters, generally mounted on the local starting panels, to indicating and recording receivers in the central control room.

A public address system provides for quick and effective communication throughout the plant.

Acknowledgments

The station was designed and constructed by United Engineers & Constructors, Inc., of Philadelphia. For permission to print this description we are indebted to H. H. Plank, vice president of the Delaware Power & Light Co. and, for cooperation in furnishing information, to Chas. W. E. Clarke, C. F. Dixon, H. G. Kitt and F. B. Smith of United Engineers & Constructors.



Exterior view of station showing temporary wall and semi-outdoor construction

ASME Semi-Annual Meeting Held in Toronto, Canada

SERVING as a demonstration of the friendly exchange of knowledge among nations of the free world and of Canadian-American amity in particular, the Semi-Annual Meeting of the American Society of Mechanical Engineers was held from June 11 to 14 in Toronto, Canada, with headquarters at the Royal York Hotel. Approximately eight hundred technical men of the two countries attended the thirty-eight sessions at which more than eighty papers were presented. The Engineering Institute of Canada participated as co-sponsor of several sessions and social events.

At the President's Luncheon, **J. Calvin Brown,** president of ASME, told of some of the progress that Canada has made in important fields of industrial endeavor, including atomic energy. He mentioned a report of the National Research Council of Canada which stated that the Chaulk River pile, its atomic energy project, has the highest neutron flux ever recorded among the world's known nuclear reactors. The pulp and paper industry, according to Mr. Brown, is the largest consumer of hydraulic and hydroelectric power and leads all other manufacturing industries in Canada in net value of production.

R. J. S. Pigott, presidential nominee

Dr. C. J. Mackenzie, president of the National Research Council of Canada, delivered the Roy V. Wright Lecture. He declared that Canada and the United States must expand their "conception of community interest and responsibility" to include "all people of good will" everywhere if the global struggle for democratic freedom is to be won. Urging engineers to serve on local councils, boards and social welfare to increase their understanding of government, Dr. Mackenzie also cautioned them against making the rather stupid error of assuming that human actions follow valid and consistent laws such as exist in the physical sciences. Workable solutions to social problems are not necessarily found by simply applying the laws of physical science.

At the EIC-ASME Joint Luncheon **Ira P. MacNab,** president of the Engineering Institute of Canada, urged that the engineering curriculum be broadened to equip engineering graduates for the wider duties of citizenship and the many executive roles in industry that they are asked to assume. Considering the part played by engineers in creating the present way of living, it is doubtful if they are carrying their share of the load as citizens.

R. J. S. Pigott of Pittsburgh, Pa., since 1929 director of engineering of the Gulf Research & Development Co., was nominated to be president for 1952. Active in society affairs since joining in 1912, Mr. Pigott was made a Fellow in 1938.

Regional vice presidents nominated are:

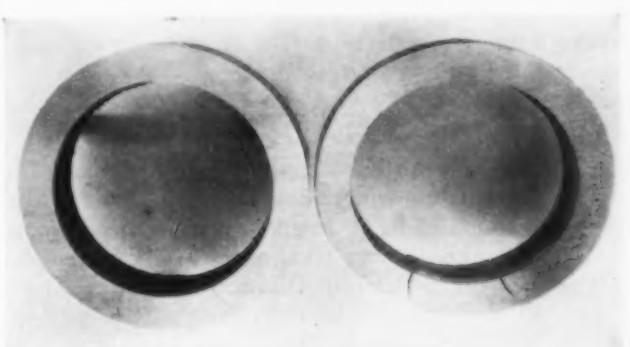
Willis F. Thompson, chief mechanical engineer, Westcott & Mapes, Inc., New Haven, Conn; Ernest H. Hanhart, consulting mechanical engineer, Baltimore, Md.; Ernest S. Theiss, assistant chief engineer, Davey Compressor Co., Kent, Ohio; and Samuel H. Graf, (renomination), director, Engineering Experimental Station, Oregon State College, Corvallis, Ore.

Nominated as directors-at-large:

Albert C. Pasini, superintendent of production, The Detroit Edison Co., and Paul B. Eaton, head of the mechanical engineering department, Lafayette College, Easton, Pa.

Ultrasonic Field Inspection

How ninety boiler tube sections representing over 1500 ft of defective tubing were detected and replaced was explained by **J. A. Tash** of the Duquesne Light Co. in a paper entitled "Field Inspection of Boiler Tubes with Ultrasonic Reflectoscope." Tube failures first occurred in the convection superheater outlet section of a 600,000-lb per hr two-furnace boiler after 1200 hr of service. Examination disclosed that the ruptures developed along one or more longitudinal seams originating at the inner surface and penetrating 75 to 90 per cent of the tube wall. The primary considerations in the search for an inspection method were ability to distinguish between good and bad tubing and adaptability to confined working conditions in the boiler. Since



Sections of tube showing the seams as following a regular curve and leaving little residual metal near the outer surface

testing involved nearly ten miles of superheater tubing speed was also a consideration.

Upon investigation it was found that the ultrasonic Reflectoscope could be used satisfactorily for inspection purposes. It consists essentially of a pulse generator, an oscilloscope and a searching unit. The procedure followed was similar to that described by C. D. Moriarity at the ASME 1950 Fall Meeting.[1] The searching unit was mounted in a special plastic adapter shaped to the contour of the tubes and was rocked back and forth over 90 to 100 deg of tube circumference while being moved lengthwise along the tube. Defects could then be recognized on the oscilloscope screen. As a means of comparison a short section of defective tubing was used

Making oscilloscope examination in restricted space

which enabled the operator to differentiate between good and defective pieces.

Because of the limited space in the boiler and the necessity for the operator to see the oscilloscope screen at all times some problems were encountered. However, it was possible to make an inspection of such a confined area as the last pass of the convection superheater where there were only 20 in. of working space between the face of the tubes examined and the refractory baffle.

Spreader-Stoker Tests

In a paper entitled "Methods of Reducing Dust Emission from a Spreader-Stoker-Fired Boiler Furnace" **W. C. Holton** and **R. B. Engdahl** of Battelle Memorial Institute reported on 47 tests made at the boiler plant of the Brown-Lipe-Chapin Division of General Motors Corp., Elyria, Ohio. The tests were carried out on a Wickes 60,000-lb per hr four-drum bent-tube boiler fired by a Detroit Rotograte continuous-ash-discharge spreader stoker consisting of three feeders. Bituminous Coal Research, Inc., organized the project, which was participated in by a number of stoker manufacturers.

The most significant results of these tests are as follows:

1. Jet turbulence, whether provided by steam or by air, is needed to assure low smoke densities required by municipal ordinances. The use of overfire jets also reduces the carbon loss and dust emission from the furnace.

2. Reinjection of cinders from the boiler hoppers decreased carbon loss 2.3 to 4.1 per cent, while increasing dust loading from 20 to 40 per cent. Returning all the collected cinders (from both boiler and collector hoppers) to the furnace gave a further decrease in carbon loss of 2.1 to 2.8 per cent at the expense of an increase in dust loading of 125 to 155 per cent.

3. The use of coal containing a small percentage of minus $^1/_8$-in. material resulted in lower values of carbon loss and dust loading at the furnace outlet than were found with the finer coal. This decrease was not so great at either the boiler outlet or the stack. In no case was the dust loading at the boiler outlet reduced enough by burning double-screened coal to enable the plant to meet the proposed smoke ordinances without the use of a collector. Coal size had a negligible effect on smoke density. Oil treatment of coal had no appreciable effect on dust emission.

Symposium on Centralized Control and Small Gages

The first paper, "Modern Methods and Equipment for Control of Steam Generators" was by **P. S. Dickey** of the Bailey Meter Co. In general, the development of supervisory control stations for directing the operation of large steam generating units has kept pace with plant design. One area for improvement is in making a more concise picture of important operating conditions in a limited space. This in conjunction with functional arrangement of instruments and supervisory controls may enable operators to meet emergency conditions with greatest efficiency and freedom from errors.

Studies indicate that complete supervision of the large boiler and turbine units requires 300 or more points of measurement and control per unit. They also point to the following general conclusions regarding arrangement of the centralized supervisory control station.

1. A common control station for two large boiler-turbine units has the advantages of central location, minimum piping and wiring, and good utilization of supervisory manpower.

2. Control panels should be compacted as much as possible to minimize the distance to be covered by the supervising operator.

3. Functional arrangement of instruments and controls is likely to provide greater operator efficiency and to minimize operating errors.

4. Audible and visible annunciator systems should be provided to notify the operator of abnormalities and should be grouped with the indicating instruments wherever possible.

5. The control station should preferably be ar-

[1] "Ultrasonic Flaw Detection in Pipes" by C. D. Moriarity, reported in COMBUSTION, **22**, 49–50 (October 1950).

ranged to permit reasonably good visibility of the boilers and turbines.

6. Principal indicators and controls should be placed nearest the operator's station for maximum accessibility in case of emergencies.

C. H. Smoot of Republic Flow Meters Co., in a paper entitled "Electronic Combustion Control," outlined an electronic servo system used for coordination and information transmission in central station combustion controls. Equipment of this type eliminates the distance lag of pneumatic systems and enables a completely electrical panel installation. The basic principle of operation of this equipment is a self-balancing alternating-current wheatstone bridge.

"Considerations in the Use of Smaller Instruments and Their Relation to Centralized Control" was the topic of a paper by **T. W. Jenkins, Jr.,** of Leeds & Northrup Co. In the design of an operating panel the first consideration is to provide the operator with the operating devices and information necessary to carry out his work. There are several ways in which operating panel size may be minimized. The devices on the panel may be eliminated, located elsewhere, combined or reduced in size.

In eliminating devices from the operating panel some apparatus may be placed under complete automatic control. Improvements have been made in certain electrical automatic-control equipment so that no additional devices are required on the panel board beyond the requirements for manual control. If devices are to be located elsewhere, full consideration must be given to the value to the operator of these devices, taking into account their usefulness under abnormal conditions.

Considerable progress has been made in the field of combined instruments, and with the increasing use of transmitters this field may be further expanded. One example is the combination of a temperature and position indicator for damper control of mills and air heaters. As far as reducing the size of panel-mounted devices is concerned, there are definite limitations imposed by required accuracy and readability. Reliability of instruments places another limitation on reduction in size. As the size of a panel board is reduced corresponding changes must be made in the methods of wiring and piping panel boards; also the matter of accessibility in maintenance and testing is a consideration.

M. D. Engle and **H. F. Hatfield** of Pennsylvania Power & Light Co. were authors of a paper entitled "Centralized Control for Steam-Electric Generating Stations." Control rooms should be provided with adequate recording and indicating instruments, annunciators, alarms and controls, communication systems to all parts of the station, adequate non-glare illumination and air conditioning. They should be large enough without undue crowding of either side of the panels and with sufficient space for maintenance and calibration. Instrument boards should be shock mounted to reduce vibration and wear. Noise level should be low, and air conditioning should be installed for the comfort of operators and protection of delicate mechanisms in instruments and controls. There should be adequate file space for wiring and piping diagrams, station logs, instructions and records. Sanitary facilities and a kitchenette should be provided.

The ultimate aim should be to centralize the supervisory instruments and controls for the entire station in a few control rooms. At present a single room might contain the centralized control for the major equipment and auxiliaries for two units. It might be well to defer bringing into the main control room those controls with less bearing on the immediate operation of the main equipment and requiring infrequent attention of the control-room operators. These include coal-handling equipment, ash and dust-handling equipment, dust separators and water-treatment plant.

"Remote Operation Through Centralized Control Rooms—A New Concept Developed on the American Gas & Electric System" was the topic of a paper by **T. T. Frankenberg** of the American Gas & Electric Service Corp. For true remote operation it should be possible to light off the boiler, bring the turbine from rest to full load and then shut down the unit without occasion for leaving the control room. Such operation is being obtained on several units now in service, and still further refinements are contemplated for plants in the design stage. A study of forced outages on the author's system indicated that many equipment failures were of a nature that would require a unit outage regardless of the number of men available. It appeared that, statistically, very few additional shutdowns would result from minimizing the operating force, and that freedom from operating errors would overcome the disadvantage of having fewer people in the plant.

To convert a centralized control room into a tool for realizing complete remote operation requires a survey of various operating conditions that may arise and consideration of the way in which they will be handled. Some items to be considered include accidental tripping of the generator, loss of vacuum, boiler tube failure and loss of ignition. Conditions about which the operator can do nothing, such as a boiler tube failure, or in which the corrective action can be postponed, such as the partial plugging of a service water strainer, do not warrant bringing any further items into the centralized control room. On the other hand, those which require the immediate and intelligently directed efforts of the operator, such as loss of ignition, justify extra expenditure for remote operating equipment. It will be found necessary to have such equipment as remotely operated oil torches, full control of burner and secondary-air dampers, and burner television to cope with loss of ignition.

Model Tests of Piping

Lale C. Andrews of the M. W. Kellogg Co. presented a paper entitled "Piping Flexibility Analysis by Model Test" in which he pointed out that this method permits

analysis of a very intricate piping system as a unit. While the time required for mathematical analysis increases divergently with the complexity of the problem, with model tests the time required per point of restraint becomes less as their number increases. Hazards of overdesign and underdesign resulting from the practice of breaking down a complex problem into simpler ones that are within the scope of mathematical methods are avoided in model testing. It is the simplest available method for obtaining the loads on intermediate restraints and is particularly useful where many solutions are needed for a single layout with different temperature conditions. Deflections obtained from model tests have been corroborated by field measurements.

The author described model tests of steam lines in which the superheater terminal elements are continued through and over the boiler roof to a header at the front end of the boiler housing, thereby increasing the flexibility of the piping system. Since the maximum stress often occurs at or near the end points, the terminal parts of the system must be given as careful consideration as the main run of pipe. At the boiler end the useful flexibility of tubes, for a given horizontal length, can be increased substantially by increasing the vertical legs, both in front and at the rear. This design generally permits the tubes to assume a configuration that tends to reduce substantially the stresses in them. In general, it is easier to design for the required flexibility if the longitudinal center line of the turbine is parallel to, and preferably a continuation of, the center line of the boiler.

Marine Engineering

Four papers were presented under the auspices of the Power Division on the subject of marine practice. Three of these papers dealt primarily with particular problems encountered on the Great Lakes.

Commodore **A. C. M. Davy** of the Department of National Defense, Canada, traced the history and discussed the present state of marine engineering in Canada. He noted that in the days of wooden ships during the 19th Century Canada ranked as high as fourth among the trading nations of the world. With the exception of the stimulus brought about by World Wars I and II, the sea-going shipbuilding industries have had relatively little activity other than repair work.

On the other hand, the Great Lakes account for a major part of the Canadian maritime industry. Commodore Davy characterized the ships engaged in lake traffic as tending to be "conservative in design, functional in extreme" and yet having "proved themselves suitable to the job." He briefly described the tankers which are being built for the Imperial Oil Transportation Co. to carry oil from the end of the Alberta pipe line to the oil refineries at Sarnia, Ontario. These ships are the largest tankers ever built for fresh-water service and are geared-turbine driven. They have an overall length of 620 ft, a molded breadth of 68 ft, design draft of 24 ft, displacement of 21,600 long tons, cargo-carrying capacity of 115,000 barrels of crude oil at design draft, shaft horsepower of 4500, and design speed of 13 knots.

"Geared-Turbine Repowering for Great Lakes Vessels" was the title of a very comprehensive paper by **B. E. Ericson** of Pittsburgh Steamship Co. and **F. H. Van Nest** of General Electric Co. At present the Great Lakes Cargo fleet numbers approximately 600 vessels, over 85 per cent of which have reciprocating engines and Scotch marine boilers. The age of one-third of the ships is in excess of 40 years, while one half are between 20 and 40 years old. Operating speeds are 10 mph or less. To meet immediate demands for ore-carrying capacity one possibility is to repower existing vessels to increase horsepower, speed and seasonal capacity. The paper discusses some of the design features and economic considerations of the geared-turbine installation aboard the *Homer D. Williams*, a standard 600-ft ore carrier built in 1917 and originally powered by a jet-condensing triple-expansion engine and three Scotch boilers.

Typical Great Lakes operation involves relatively short and intermittent periods of running at sustained full speed, much running at reduced speeds in congested or restricted waters, and maneuvering in and out of port. It does not justify design refinements that would be expected in central stations, fast naval vessels or large ocean-going tankers. For a new vessel with a geared-turbine installation of 7000 shp, a fuel saving of about three to four per cent might be anticipated by using steam at 600 psig, 825 F instead of 450 psig, 750 F. First cost and engineering considerations do not allow even that level of steam conditions and design refinement for a repowering project.

The *Homer D. Williams* has been repowered with a single-cylinder turbine flexibly coupled to a double-reduction, locked-train single-helical gear set rated at 3000 shp. Turbine rotor speed is 8000 rpm and propeller speed is 110 rpm. Steam conditions at the turbine inlet are 440 psig, 740 F. The turbine is much smaller in size and lighter in weight than the present steam engine and will provide about 50 per cent more power at a much lower rate of steam flow. Factory tests of the turbine and gear were reported as very satisfactory.

George J. Kirschner of Foster Wheeler Corp. had as his topic "Reboilering the *Homer D. Williams*." Because much of the auxiliary equipment of this vessel was far too good to be disposed of, the steam cycle and physical arrangement were adapted to its use. The contaminated exhaust steam from the reciprocating auxiliaries instead of being discharged to the condenser is led to a first stage heater or heat exchanger where it gives up its heat to the feedwater and is then pumped overboard. There is more than enough exhaust steam for feedwater heating, and the uncontaminated exhaust from the turbine-driven auxiliaries is introduced into the low-pressure end of the main turbine, adding about 100 hp to the normal capacity.

Raw lake water for boiler feed is treated in a zeolite system operating on the sodium cycle and having a capacity of 1000 gal per hour. Although the usual practice has been to install air heaters when reboilering with coal-fired water-tube boilers, it was decided in this case to burn oil and to install economizers. They were chosen because of their relative freedom from soot fires and because corrosive action is reduced when the

economizer tubes are covered with a protective material such as cast iron.

Two Foster Wheeler single-pass "D" type boilers were installed, each having a normal rating of 15,000 lb of steam per hour and superheater outlet conditions of 450 psig, 750 F. The firing rate is controlled by an all-electric system which regulates the quantity of air and oil supplied to each furnace in proportion to the boiler's total load as indicated by superheater outlet steam pressure.

The fourth paper on marine engineering was by **S. F. Mumford** of Combustion Engineering-Superheater, Inc., who discussed "Some Developments in Marine Boiler Design." This paper appears in condensed form elsewhere in this issue.

Turbine Supervisory Instruments

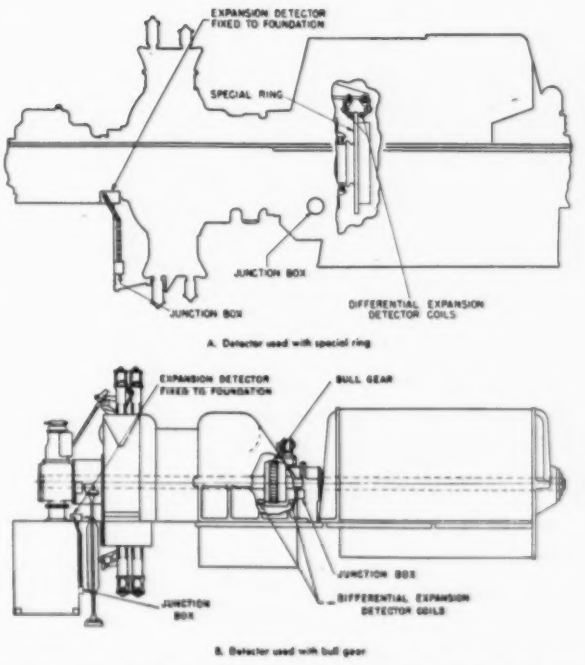
E. Y. Stewart and **J. H. Reynolds, Jr.,** of the General Electric Co. submitted a paper entitled "Supervisory Instruments for Power Generating Equipment—Application and Interpretation of Records." In developing these instruments one important problem was to design electronic equipment having a reliability comparable to that of the steam turbine. To aid in maintaining reliability, built-in test circuits are incorporated in the supervisory instruments.

Equipment is available to record turbine conditions in terms of shell and differential expansion, speed and camshaft position, bearing vibration and shaft eccentricity. The shell and differential expansion recorder consists of a strip chart recorder, a power unit and two detector units mounted on the turbine and connected alternately to the measuring circuit through a time switch. The reading of the differential expansion detector is a measure of the clearance between rotating and stationary elements in the turbine. Danger bands are placed on the recorder scale so that the operator may know when clearance is decreasing to the point that rubbing may be expected.

The speed and camshaft position recorder chart is marked in terms of speed in revolutions per minute when the machine is being brought up to speed and of camshaft position in per cent open when the machine is synchronized and placed on the line. The bearing vibration scale is designed so that five detectors can be recorded in sequence on a logarithmic scale ranging as high as 15 mils. The shaft eccentricity scale is linear and consists of separate scales for turning gear and steam operation.

The shell and differential expansion recording equipment indicates the amount of forward expansion of the turbine shell and the differential expansion between the shell and turbine rotor. The measurement of differential expansion not only provides an index as to the operating clearances but also gives valuable information for proper starting and operating procedures.

The speed and camshaft position recording equipment records the speed when starting up and shutting down the turbine and also gives a measure of the load that the machine is carrying in terms of per cent rotation of the camshaft. It is valuable in analyzing events when the line breaker of the generator opens due to system disturbances.



Location of shell and differential-expansion detectors on steam turbine

Bearing vibration recording equipment indicates the amount of vibration on each of the main bearings in sequence. It detects disturbances which cause high vibration and long-time changes in vibration due to misalignment.

Shaft eccentricity recording equipment detects and records once-per-revolution shaft bow and is helpful in detecting a loose thrust sleeve or runner in advance of actual failure.

The authors cited a number of case histories in which turbine supervisory instruments of the types mentioned enabled the detection of impending trouble.

Coal-Burning Gas Turbine

A small experimental coal-burning gas turbine is now being designed and constructed by the Gas Dynamics Laboratory at McGill University, Toronto, Canada. **Prof. Donald L. Mordell** described modifications of the exhaust-heated cycle on which the unit is to operate and steps which have been taken to reduce heat-transfer surface and to permit easier manufacture. The thermodynamics of the revised cycle are outlined and general data on heat-exchanger sizes presented.

The starting point of the experimental unit is a Rolls Royce propeller-turbine engine. This engine has a two-stage centrifugal compressor and a two-stage axial turbine. The heat-exchangers and furnace being designed will permit the development of some 600 hp. In designing the unit no attempt has been made to produce a compact layout, the main emphasis being to produce a versatile and flexible experimental unit. Room has been provided to permit the testing of different combustors and heat-exchangers and, eventually, alternative cycle arrangements.

Facts and Figures

Lubricants account for about two per cent of the total volume of major petroleum products.

•

Through the fiscal year 1951 nearly five billion dollars will have been spent by the U. S. Government for the development of atomic energy.

•

The consumption of anthracite in non-fuel uses accounts for over a million tons per year.

•

According to the American Petroleum Institute, wildcat drilling for oil has one chance in every nine of being successful.

•

Gas turbines are not self-starting; hence they must be cranked by a starting motor. They become self-sustaining upon reaching about half normal speed.

•

Private electric utilities in this country are reported to have invested more than eight billion dollars in new plants since 1945.

•

Vast peat deposits are reported to have been discovered in Israel and are being considered for large-scale power generation.

•

The output of bituminous coal mines in the United States is currently at the rate of approximately ten million tons a week.

•

The first offshore aluminum pipe line in the world has been installed by the Aluminum Company of America in Matagorda Bay near its Point Comfort, Texas, Works.

•

During the last thirty years the annual production of electricity in kilowatt hours per capita in the United States has increased approximately fivefold.

•

The Department of Commerce reports that sales of mechanical stokers of over 1200 lb per hr capacity during the first three months of this year were more than sixty per cent greater than during the corresponding period last year.

•

It has been claimed that by maintaining a pH of around 9 in the feedwater, by use of ammonia, the copper, and also the iron, solubility will be reduced to low values.

•

Boilers may be maintained in either dry or wet standby condition. For the former, they should be thoroughly drained and kept dry during the idle period, whereas for the latter method they should be completely filled with conditioned water which it is well to circulate through the boiler occasionally.

•

Accurate data on the efficiency of the combustion process in jet engines is provided by a gravimetric method of exhaust-gas analysis that has recently been developed at the National Bureau of Standards.

•

According to the Federal Power Commission, the April net income of private electric utilities was approximately 71 million dollars as compared with nearly 75 million in April of last year.

Utilities Consume Vast Coal Tonnage

America's electric utilities, which consumed nearly 92 million tons of coal in 1950, probably will consume a record 108 million tons this year, according to L. R. Ludwig, of Westinghouse Electric Corp., speaking at a luncheon meeting of some 500 delegates to the American Mining Congress Coal Show. He pointed out that these figures place electric utilities almost on a par with the steel industry as a market for the nation's coal.

"Market analysis has indicated that the total annual sales by the electric utility industry will rise from about 275 billion kilowatt-hours in 1950 to 634 billion in the next 15 years," he continued, and "using the 1950 ratio of coal to kilowatt-hours, the utilities should by 1965 be using about 211 million tons annually, or $2^1/_2$ times the present coal consumption."

The amount of coal required to generate a kilowatt-hour of electricity has declined from about 7 lb per kwhr in 1900 to the average rate in 1950 of 1.19 lb, Mr. Ludwig pointed out, and some of the newest steam plants are operating at a rate of $^3/_4$ lb per kwhr. He stated further that steam turbines of tomorrow will be larger and more economical than present machines, and added that single-shaft, 3600-rpm units with maximum capabilities of 125,000 kw are already under construction, and 150,000-kw machines are on order.

In 1900, it required three man-hours for each ton of coal mined, while today the figure has dropped to 1.28 man-hours. Only 2 per cent of the coal production at present is hand-mined, and only 25 per cent hand-loaded.

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Developments in Use of Television in Power Stations

By L. M. EXLEY
Long Island Lighting Company

An account of experience at the Port Jefferson Station of the Long Island Lighting Company leading to the application of television to furnace observation as an effective operating aid.

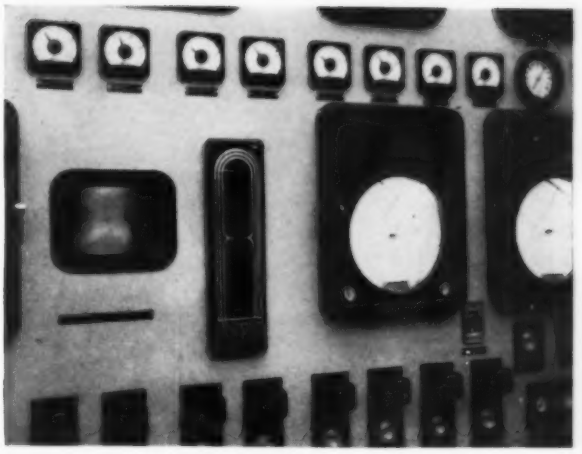


Fig. 1—Control board showing television screen at left

AT THE Port Jefferson Power Station of the Long Island Lighting Company, the application of television for direct viewing of furnace conditions has been in the process of development for some time. At present, such an installation provides the operators in our centralized control room much needed information about conditions existing in the furnace of one steam generating unit firing pulverized coal.

In the Long Island Lighting Company the tremendous value of television in the operation of a power station using centralized control was recognized, providing it could be developed to give the operators a complete, continuous story in pictures as to what is taking place in the furnace at all times as follows:

1. Preparatory to lighting off, to show that all ignition torches, which are operated from the control room, are ignited.
2. In lighting off, to show that ignition of oil or coal, has taken place and is stable.
3. To show malfunction of burners while burning oil or coal, at any rating.
4. To show loss of ignition at any time.
5. To show any condition that might result in a furnace explosion.

Development of the use of television equipment toward these objectives has been carried to its present status through the combined efforts of the Diamond Power Specialty Corporation and the staff of the Port Jefferson Power Station.

It was self-evident that if all the objectives outlined above could be obtained, the use of television would counteract one of the greatest disadvantages of remote centralization of steam generator instruments and controls. It would provide the operator in a remote location much more complete information about furnace conditions than is available in the conventional installation where he is stationed close to the steam generator unit.

Installation

As shown in the sketch, Fig. 2, the camera unit is mounted over a centrally located opening in the roof of the water-cooled furnace of a 425,000-lb per hr tangentially fired, Combustion steam generating unit. In order to provide an opening of sufficient size two bent sections of roof tubes were installed at this point. The camera lens is protected from heat by a water-cooled window. The camera unit will withstand temperatures of 150 F or over, so requires no cooling. From this camera location the picture is transmitted to the viewer, which is located on the steam-generator panel in the centralized control room.

History of Development

The two Combustion steam generators at Port Jefferson are equipped for burning either oil or coal. All oil and coal burners are arranged with tilting burners for superheat control. Secondary air dampers are operated from the control room. Both units are equipped with remote-controlled ignition torches using light oil. At the present time both units are subject to operation over a range from 80,000 to 425,000 lb per hr daily.

During preliminary demonstrations of the television equipment, oil was the only fuel being used. At that time, range of boiler operation was limited because of system loads. Under those conditions, the picture on the viewer clearly showed the burners in all four corners, the mechanics of tangential firing, the effect of tilting the burners, the cutting in and out of oil burners, and incomplete combustion when air was reduced.

Later, it was found that it was not possible to obtain a clear picture over the range from full load down to a cold boiler with the ignition torches in operation. Also, when one unit was changed over to coal firing the light intensity was so increased that much of the detail of the picture was lost.

These two problems have recently been solved by Diamond Power Specialty Corporation. Circuits were redesigned so that the output of the camera tube was limited, thereby obtaining automatic overload control. These changes have made it possible to obtain a clear

picture of the burners on coal firing. Furthermore, it is now possible to obtain a clear picture from a cold start from the firing of ignition torches, up to and including full load. No adjustments are required at the camera or viewer.

After these changes were completed and tested out, the performance of the set was recorded in pictures of the television screen on April 15 when the coal-fired unit was fired up after being out of service for 12 hours. The pictures do not show as much detail as can be seen by observing the screen directly, as photographing of pictures on television screens present many problems.

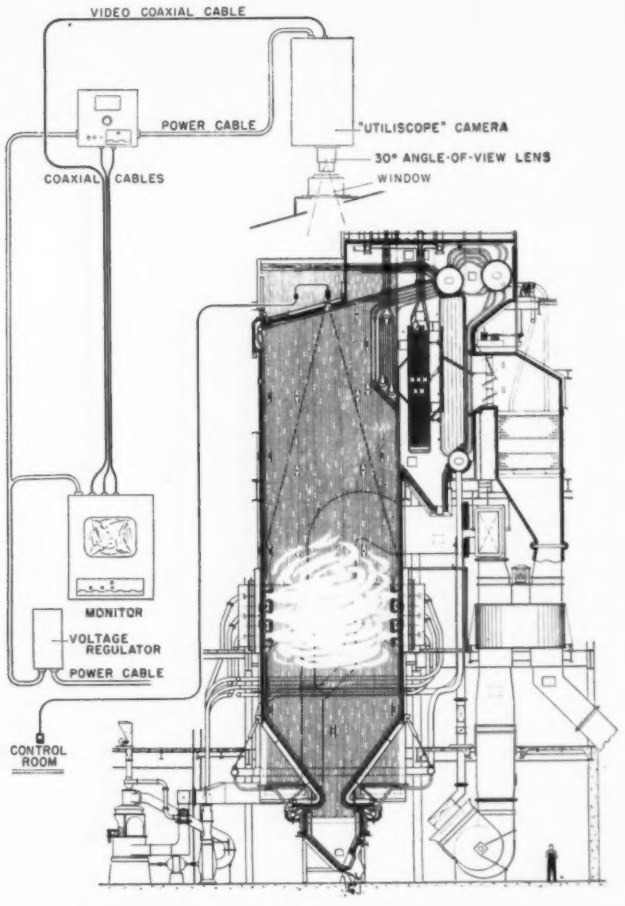


Fig. 2—Sketch showing camera location

Operating Experience and Conclusion

Based on this information it is evident that most of the objectives heretofore outlined have been obtained as follows:

1. Preparatory to lighting off, the ignition torches are shown satisfactorily on the screen in the control room and the man who operates the control for ignition of these torches can observe their operation. The four white dots in each corner of the screen, as indicated in Fig. 3, show the ignition torches.

The ignition torches ignite the pulverized burners satisfactorily when the boiler is hot. In case of loss of fire, while burning coal, the furnace will be cloudy for a short period. Ignition torches will be observed on the television screen as soon as the furnace has cleared up. When purging is completed the operator is ready to start a pulverizer and light off, all from the control room.

Fig. 3—Ignition torches only in operation

In bringing the coal-fired steam generator up to pressure from a cold start, up to the time the turbine is phased in, the light-oil burners are used. Figs. 4 to 7 show the sequence of such operations with one, two, three and four burners lighted.

2. In lighting off coal from either the light-oil burners or from the ignition torches the screen becomes black when pulverized coal is first admitted to the furnace. Ignition normally takes place in about 30 seconds. As soon as this takes place the flame pattern appears on the screen. The stability of the flame and the point at which ignition is taking place, with respect to the burner nozzles, is indicated clearly. The photograph in Fig. 8 shows the fire shortly after ignition of pulverized coal, and in Fig. 9 is shown the appearance of the flame after conditions became stabilized.

3. Television shows many burner conditions that could not be analyzed by other means, on either oil or coal, at any rating. For example, before the television was installed, during burner cleaning periods on oil firing, dark puffs were usually observed from the stack. The logical conclusion was that the operators were cutting the oil burners back in service too quickly. Television showed that the dark stack was caused by purging the oil burners too rapidly.

Fig. 4—One light-oil burner ignited

High-volatile coal from the Fairmont, W. Va., district is now being burned at Port Jefferson. The volatile matter of this coal is in the range of 36 to 39 per cent which increases the possibility of burner coking. The television equipment has been very helpful in burning this fuel, as it provides a better picture at the point of ignition than can be determined by observing the furnace through the various peepholes. Visual inspections of the burners for coking are still made periodically but coking has been almost entirely eliminated by keeping ignition further from the burners than would be considered practical without the use of television.

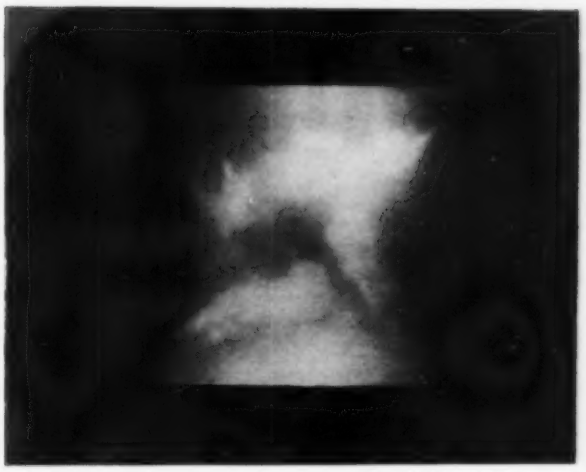


Fig. 8—Appearance of fire shortly after pulverized coal ignition

Fig. 5—Two light-oil burners ignited

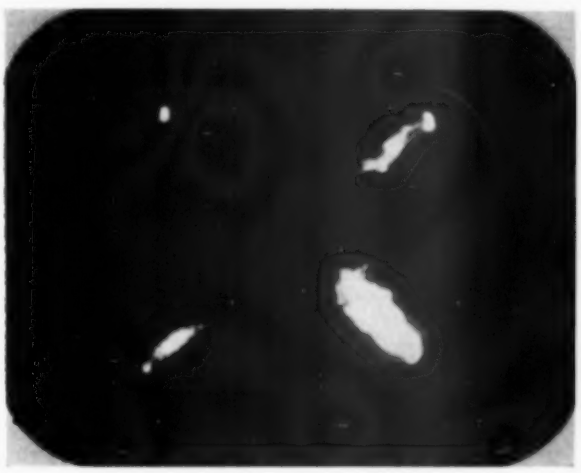


Fig. 6—Three light-oil burners ignited

Any burner condition which affects combustion, such as unequal fuel distribution, is very noticeable on the screen. Other things, such as cleaning ash from the dry-bottom hopper or blowing of the water-wall soot blowers can be also seen.

The mechanics of tangential firing and the effect of burner tilt can be observed. The fact that one burner tilt control was out of step with the rest, was noticed on the television screen.

Incomplete combustion in the furnace is readily detected in the picture on the screen, and therefore aids in maintaining a clear stack. This is of extreme importance not only in locations where rigid smoke-control ordinances are enforced, but also because of the country-wide attention being given to smoke abatement.

4. Loss of ignition due to stoppage of oil or coal flow is shown instantaneously by a black screen. The operator can verify the loss of ignition under this particular condition by observing the furnace draft gage, which always changes at loss of ignition, and pulverizer

Fig. 7—All four light-oil burners ignited

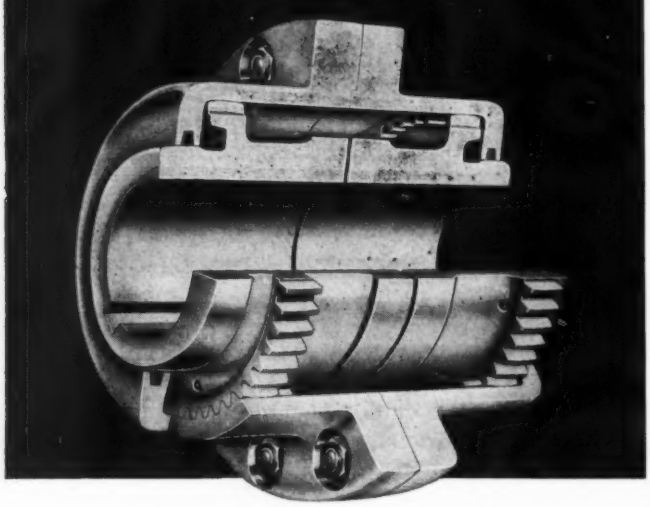
Fig. 9—Showing satisfactory flame with pulverized coal

instruments in the case of coal, or fuel pressure gage in the case of oil. Therefore, in our opinion, television provides information, if properly analyzed and checked against that normally available in any centralized control room, to definitely determine loss of ignition due to fuel failure.

5. We believe, at this time, that the television installation at Port Jefferson will assist in detecting, but not definitely show, any condition which might result in a furnace explosion. Any large reduction of air flow, without reduction of coal flow results in a rich, explosive mixture in the furnace. Under such conditions ignition is seldom lost. Such conditions may be brought about by failure of automatic controls, failure of a forced- or induced-draft fan motor, or failure of dampers in forced- or induced-draft ducts. In such cases the television screen becomes black, even though ignition is maintained. As the television camera is at the top of the furnace, unburned fuel rises and obscures the burners under such conditions. Further studies are being made at this time in order to analyze the information available on the television screen so that it can be used to assist the operators to greatest advantage.

After being in service three months, television is highly endorsed by the control-room operators as an important operating aid. In fact, they express uneasiness when it is removed from service for any reason. It holds promise of widespread application, especially among central station boiler plants.

POOLE



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Electric Power Survey

The Ninth Semi-Annual Electric Power Survey by the Edison Electric Institute, under date of April 1951, has recently become available in printed form. Part I covers capability and energy output for 95 and 98 per cent, respectively, of the nation's power systems; and Part II deals with manufacturing facilities available for producing equipment necessary to meet estimated demands. The data are based on load growth studies plus presently known defense loads, with the assumption that the required materials and labor will be available. Obviously, additional large defense loads, not yet determined, or acute material shortages would affect these estimates and delivery schedules.

In reviewing the report certain facts stand out. For instance, from a total electric energy output of approximately 277 billion kw hr back in 1948 a figure of 408 billion for 1952 is indicated, with slightly over 325 billion estimated for the current year.

Peak capability estimates are as follows:

1951—74,498,000 kw
1952—84,152,000 kw
1953—94,763,000 kw
1954—100,581,000 kw

While the program for increasing capabilities for this and next year is based on the maximum to be expected from the standpoints of new equipment and the time required for plant construction, it is recognized that load during this period may increase faster than new capacity can be brought into service.

Reserves

Reserve margins for the whole country, which represent additional capability available at the peak period to cover maintenance, emergency outages, operating requirements and unforseen loads, range from 8.5 per cent in 1951 to an anticipated figure of 16.1 per cent in 1953. Of course, these are averages and the percentages vary for different regions. For example, the 1951 percentages are given as South Central 23.4, West Central 20.9, Southwest 18.9, North Central 9.8, East Central 8.8, Northeast 8.6, Southeast −1.1, and Northwest −3.2 per cent. Since these are expressed in per cent of peak capability, the figures do not represent relative marginal capacities.

Equipment

For the seven-year period, 1948 through 1954, builders of large steam turbine-generators (10,000 kw and above) show a total of shipments and scheduled shipments exceeding 40 million kilowatts, of which 91.1 per cent applies to utilities in the United States, 4.7 per cent to industrials, and 4.2 per cent to export. The total for small steam turbine-generators is 2,589,700 kw and for the water-wheel generators 9,626,100 kw. The corresponding figure for capacity of steam generating units is 434,476,000 lb per hr of which nearly 75 per cent applies to U. S. utilities, 15 per cent to U. S. industrial plants, and 10 per cent to export. The large turbine-generator figure for 1951 is 6,474,500 kw, of which 5,124,500 represents utilities in this country. The largest shipments will be in 1952 when nearly $9^1/_2$ million kilowatts of large units will be turned out by the turbine manufacturers. On the other hand, 1951 represents the high for manufacturers of steam generating equipment with 99,856,000 lb per hr capacity, shipped, on order, or scheduled for shipment.

There will be considerable open manufacturing capacity for boilers from the middle of 1952 on. This is estimated as 50 million pounds per hour in 1952 and 140 million pounds in 1954. On the other hand, steam turbine manufacturing facilities are pretty well filled through 1953.

The report states that one of the most serious material factors is shortage of tubes for boilers, a situation which, it is hoped, responsible authorities in Washington may be able to correct.

Need for Engineers and Scientists*

A June 1951 telegraphic survey based on the requirements of 378 companies and government civilian agencies indicates that about 80,000 engineers are now needed. When the current graduating class of 38,000 is absorbed, there will still be an unfilled demand for 42,000 engineering graduates. However, a study of the 1951 class of engineering graduates showed that the military services, through R.O.T.C. reserve programs, and Selective Service, will siphon off about 19,000. Thus, the actual unfilled demand will then be for more than 60,000 engineers. The 1952 graduating classes will total only about 26,000; those in 1953 about 17,000; and 1954, about 12,000.

The increased complexity of our industry and new technological fields, such as atomic energy, the development of antibiotics, jet propulsion, electronics, etc., have made a definite upturn in the use of engineers and scientists. There are now about 1600 engineers per 100,000 workers, according to the Bureau of Labor Statistics.

Defense Demands for Engineers

The impact of partial mobilization has caused another sharp increase in the demand for engineers to speed up and improve the design, development and production of the implements of modern warfare and the other essential defense and civilian needs, and for the expansion of existing plants and facilities so vital to the national defense.

It is not possible to determine from the answers obtained whether the sharp increase in demand is due to the tooling-up needs of a partial mobilization or because of the extreme technological advance of the past several years and the increased use of engineers and scientists by various organizations and agencies. There is some reason to believe that much of the increase may be a long-term trend.

The Engineering Manpower Commission of Engineers' Joint Council is deeply concerned over the magnitude and probable consequences of the shortage of engineers and scientists to the national health, safety and interest. Studies will continue to be made to determine to what extent the shortage is a short-term or a long-term problem and what efforts can be made to aid government, private enterprise, and others in determining policies to promote the most effective utilization of engineers and to aid in maintaining the supply so that our technological superiority will not suffer.

* From a report presented at the Annual Meeting of the American Society for Engineering Education, at Michigan State College, June 25-29.

WHY STANDARD DP TURBINE DRIVES FIT ALMOST ANY APPLICATION

Here's a turbine designed by turbine users. It incorporates the features asked for by hundreds of operators interviewed in an exhaustive survey. They told General Electric they wanted a mechanical-drive turbine that would fit many types of applications—continuous process, standby, indoor, outdoor, equipment drive, generator drive, etc.

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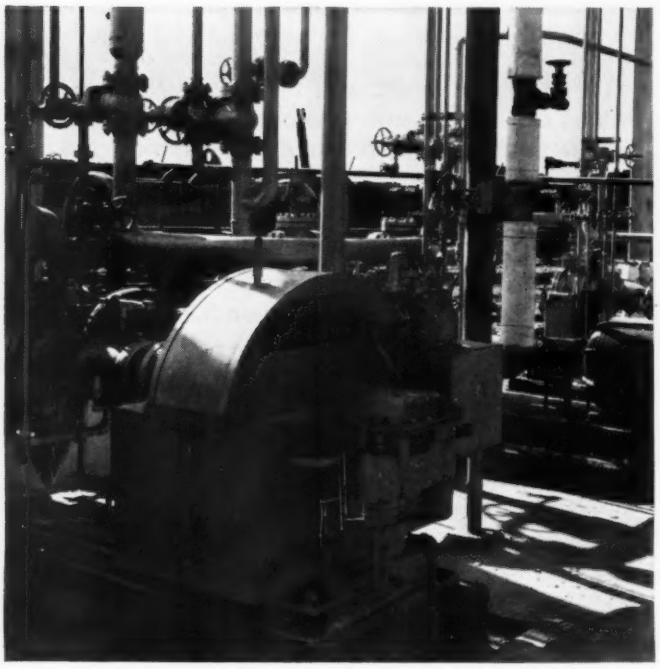
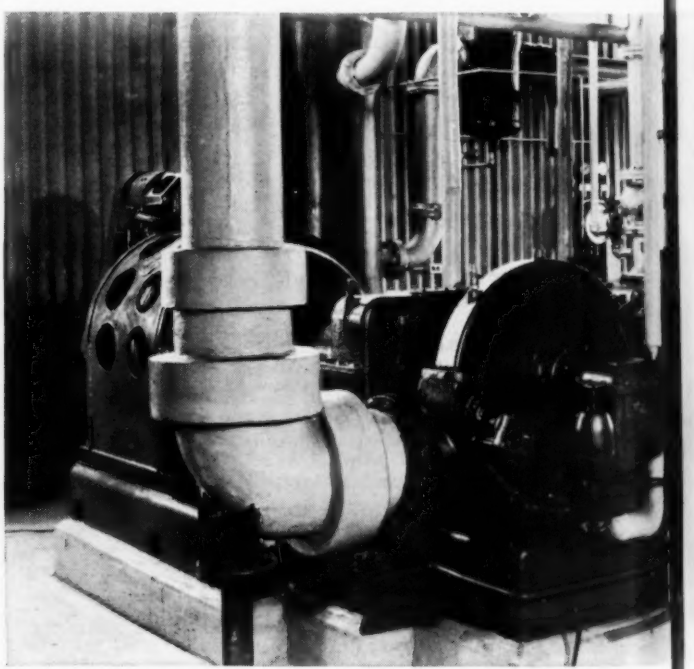
If you have steam available, the DP turbine can work profitably for you. You'll discover how its standard design gives you wide application flexibility, makes possible real savings in maintenance costs. The DP's operating record proves its reliability when there's a tough job to be done.



OUTDOOR INSTALLATIONS—No need to make special modifications when you move a DP out of doors. Totally enclosed governing system operating in its own oil atmosphere eliminates possibility of rusting or corrosion. You can operate a DP in hazardous atmospheres. Positive acting, non-sparking emergency governor protects the DP turbine against overspeed.



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GENERAL ELECTRIC

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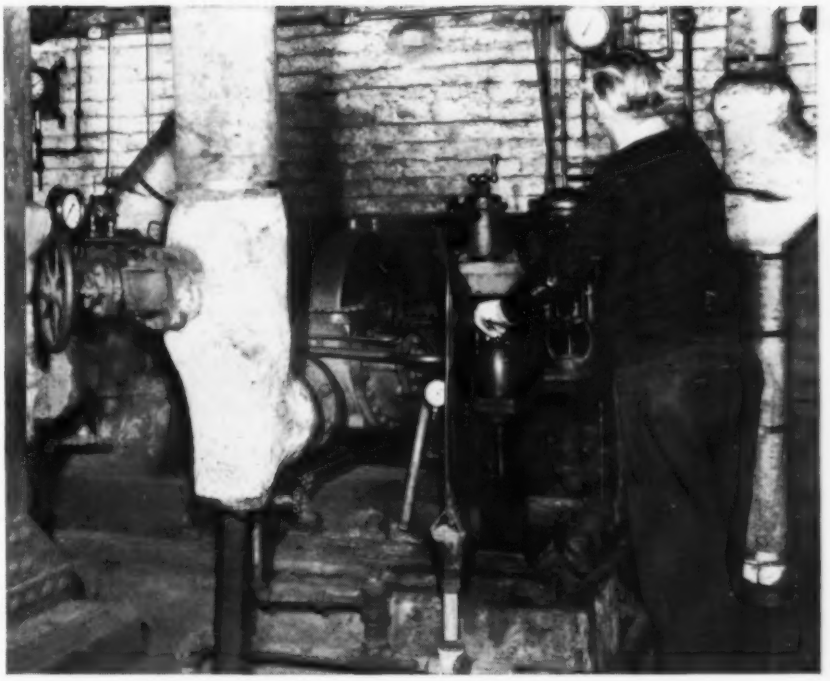
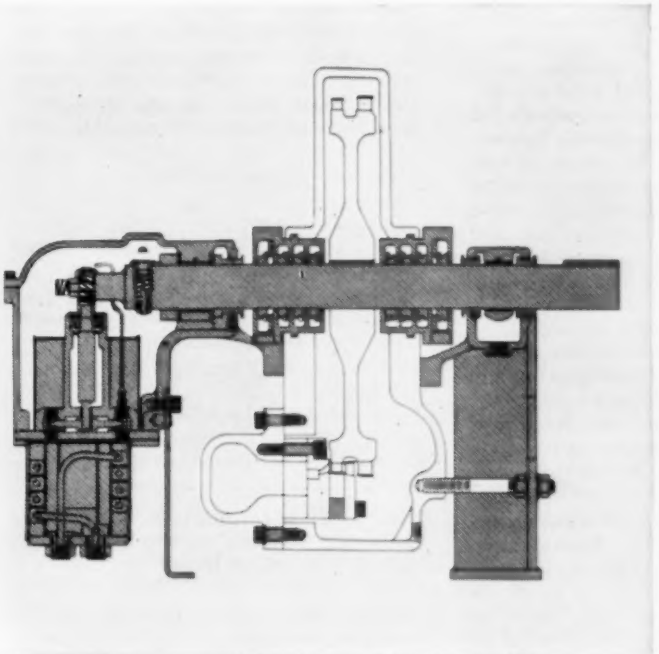
MECHANICAL-DRIVE TURBINES



DEPENDABILITY is built into the DP. Positive lubrication through automotive-type bearings adds years to the life of the turbine. Special steel nozzle plate, self-lubricating graphite packings, and Monel-sprayed shaft are examples of design features that spell reliability.



APPLICATION FLEXIBILITY As the shaded parts in the diagram illustrate, most DP parts are identical on all frame sizes and ratings. In this way, you can adapt a DP for different job requirements with only minor changes. A different nozzle plate gives you a new horsepower output. A change in governor gears provides a new speed range. DP's are rated from 10 to 1200 HP and 1000 to 5000 rpm, and with slight modification, can deliver up to 2000 HP and 10,000 rpm. During a change in plant operation, the DP's flexibility will save you money.

EASY MAINTENANCE Because most parts are interchangeable on all models, spares can be stocked at low cost. A spare parts kit, containing 91 items, can be obtained with the turbine. This simple method of stocking spares lowers maintenance costs and provides protection for several DP's in your plant. All models, regardless of frame size, horsepower, or speed ratings, have identical shaft height, keyways, and coupling fits. Thus, installation problems are simplified; you can move these center-line supported units from job to job without a custom line-up.

Developments in Marine Boiler Design*

Since space for boilers aboard ships is limited, they must be compact yet designed for accessibility, low maintenance and high efficiency. Water-cooled furnace walls permit efficient combustion in relatively small furnace volume. The inherent advantages of the controlled-circulation boiler make it ideally suited for high-pressure and high-capacity marine applications.

By S. F. MUMFORD

Chief Engineer, Marine Dept.,

Combustion Engineering-Superheater, Inc.

ONE of the principal differences between marine boilers and those designed for comparable steam conditions for stationary plants is size. Generally, marine boilers are considerably smaller, as they must be designed to fit limited fireroom space.

Two relatively compact types, thoroughly proved in marine service, are the sectional-header and two-drum bent-tube designs which have been built for a wide range of capacities, pressures and temperatures. Frequently, the boiler specified is based on the operator's desire to obtain the type of unit with which he has had satisfactory results or with which his operating engineers are familiar.

Both types employ extensive use of water-cooled furnace walls, permitting furnaces of small volume, closely spaced small diameter tubes, extended surface economizers and partial or complete air casings, all of which contribute to the design of a small, yet highly efficient unit.

Controlled Circulation

As the operating pressure is increased, the difference in density between steam and water, upon which natural circulation is dependent, is reduced as may be noted from Fig. 1. Steam and water passages of ample size to assure an adequate supply of water to the generating surfaces and to permit a continuous upward flow of steam as generated are necessary. With controlled circulation boilers these limitations do not exist since all resistances to flow are overcome by one or more circulating pumps.

Tubes of considerable length may be used in this type of boiler, and since they may be placed in any position, the design and arrangement of the heating surfaces can be freely adapted to any space requirement. The drum and circulating pump need not be located in any fixed relationship to the steam generating surfaces but may be installed in any suitable location. The inherent design flexibility permits complete accessibility to all pressure parts.

Small diameter tubes, which are most effective in the absorption of heat and which are light in weight, are used for the heating surfaces. Very high rates of absorption are possible without danger of tube failures since circulation is positive and controlled. The circulation of the entire boiler is not only controlled but also accurately distributed in such a manner as to provide each circuit with the correct amount of water, according to its steam generating capacity, as determined by its position in the system.

The circulating pump is started up before lighting off the boiler, thus establishing circulation to all generating surfaces. As a result, after the boiler is lit off the temperature of the pressure parts increases rapidly and uniformly, allowing the boiler to be placed on the line very quickly without endangering the steam generating surfaces.

An indication of the relative size of a boiler of this type compared with a natural-circulation stationary boiler designed for the same evaporation but for considerably lower operating pressure and temperature is shown in Fig. 2. It will be noted that the complete marine unit could be fitted within the furnace of the stationary unit with space to spare.

The controlled circulation boiler with its advantages of compactness, light weight, complete accessibility, stable water level, fast steaming and adaptability to limited or unusual space conditions is ideally suited for high-pressure or high-capacity marine applications, as evidenced by its selection for recent Naval combat ships in which space is extremely limited and light weight is paramount.

Economizers

In an economizer the average temperature difference between the feedwater and the gas is low, usually in the range of 200–250 F for most marine boilers. The transfer rate cannot be increased without incurring a substantial increase in the resistance to gas flow. Therefore, application of extended surface which results in a considerable increase in the heating surface per lineal foot, up to eight times greater than that of a bare tube, is desirable. It permits a marked reduction in the number of economizer elements and therefore the number of header joints.

Most marine economizers are designed for counterflow of water and gas. Interruption or reduction of feedwater flow, which may occur during rapid maneuvering increases the temperature at the element joints especially in the outlet header. To avoid the possibility of joint leakage, due to this thermal shock, the expanded elements are seal-welded to the headers. Hand-holes are properly positioned to permit expanding of the elements and to allow seal-welding of the elements to the inside surface of the header. Handhole plates are designed to be used with gaskets or to be seal-welded. They are available

* Excerpts from a paper presented at the ASME Semi-Annual Meeting, Toronto, Canada, June 11–14, 1951.

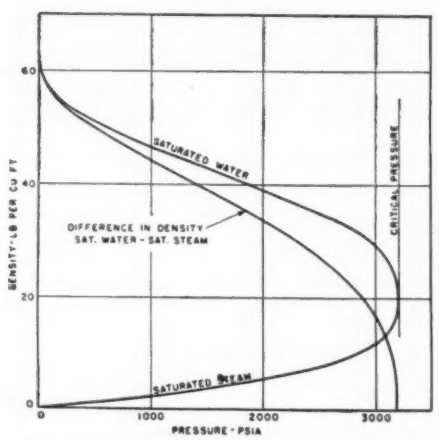


Fig. 1—Density of saturated steam and saturated water vs. absolute pressure

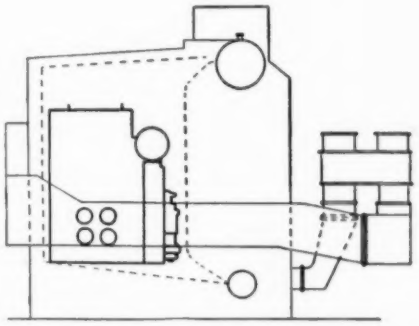


Fig. 2—Size comparison, stationary boiler vs. marine controlled-circulation boiler

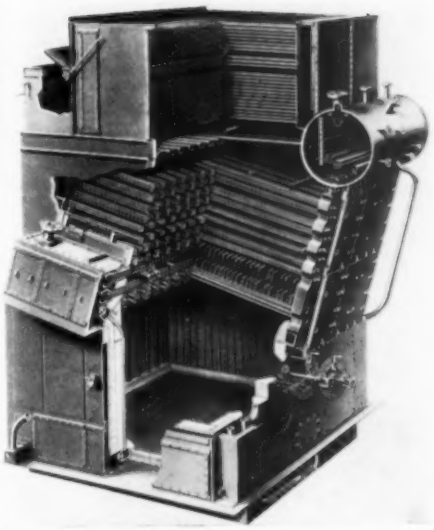


Fig. 3—Oil-fired sectional-header boiler with water-cooled side and rear furnace walls, superheater and tubular air heater

with machined seating surfaces and with shoulders for seal-welding. The shouldered plates, installed without gaskets, are seal-welded to the outside surface of the header.

If there is a possibility of the continuous loop element becoming difficult to handle, due to its height, two elements with intermediate headers may be used. This avoids the necessity of making a strength weld, in a difficult welding position in the field, and therefore eliminates a possible source of leakage.

It is essential to provide adequate means for access to all boiler parts. About ten years ago most specifications covering marine economizers required that provision be made for mechanical cleaning of the water side of the elements. Cleanout fittings were usually installed in the return bends of continuous-loop economizer elements. These fittings passed through and were sealed at the inner casing. However, experience has indicated that with good feedwater conditioning, mechanical cleaning of the water sides is unnecessary. Taking advantage of this experience, the cleanout fittings have been omitted in recent designs, thus permitting simplification of the inner casing construction and providing greater accessibility for inspection.

Shop Assembly

It has been the practice to furnish some boiler components assembled. All economizers and air heaters are supplied as completely assembled units, their casings designed to facilitate attachment to the mating boiler casing in the field. Each section of a sectional-header boiler is shipped with generating tubes expanded into the uptake and downtake headers. Some water walls are furnished with tubes expanded into the inlet and outlet headers. Many times relatively large sections of casings are preassembled at the boiler manufacturer's shop. Shop assembly of such components reduces shipyard erection time and expense.

Small auxiliary boilers are supplied as a complete shop assembled unit, ready for operation when connected to the ship's electrical, fuel and feedwater systems and stack. The fuel oil pump, feedwater pump and forced-draft fan, which are driven by a single electric motor, are mounted on a frame attached to the boiler front.

Main boilers, capable of continuous operation at evaporations up to about 25,000 lb of steam per hour, are available as shop assembled units. The assembly consists of all of the pressure parts including the drum, drum internals, water walls complete with downcomers and risers, superheater, casing and most of the refractory and insulation. Refractory is omitted at the tube joints to permit visual inspection during field hydrostatic tests.

Attachments are provided for lifting the unit on the railroad car, securing it to the depressed car during shipment and lifting it from the car into the ship. Heat-recovery equipment is shipped as a separate assembly ready for placement on the boiler at the shipyard. With such complete shop assembly the shipyard's cost and time for installation is reduced to a fraction of that usually required since only a few items of equipment, such as boiler appurtenances, soot blowers, controls and fuel burning equipment are installed in the field.

Furnaces

Frequently furnace conditions are judged on the basis of heat released per cubic foot of furnace volume. A much better criterion for evaluating furnace conditions is the heat released per square foot of effective radiant heat-absorbing surface. The rate at which heat is absorbed by radiation by each square foot of surface is a function of the rate at which the heat is released. The furnace temperature is dependent upon the heat not absorbed by furnace radiation, i.e., the heat remaining in the gases leaving the furnace and passing to the boiler convection surfaces.

For example, the oil-fired sectional-header boiler illustrated in Fig. 3, which is typical of a type recently installed on Lake boats, has both side and rear water-cooled walls. As will be noted from Table 1 the furnace heat release rate per cubic foot of furnace volume is 71,000 Btu per hr whereas the release rate per square foot of effective radiant heat-absorbing surface is 162,000 Btu per hr. If the water walls were omitted from this boiler, and some air heater or boiler surface were added to maintain the same efficiency, and the same firing rate maintained for a given evaporation, the release rate per cubic foot of furnace volume would remain unchanged but the release rate per square foot of effective radiant absorbing surface would increase to 378,000 Btu per hr. The furnace temperature would rise from 2430 F to 2700 F.

To attain the same furnace temperature, 2430 F, without water cooling on the furnace walls, it would be necessary to increase the boiler width from 7 ft 0 in. to 16 ft 4 in., an increase of 133 per cent. The furnace release rate per cubic foot of furnace volume would be considerably reduced but would not be indicative of actual furnace loading.

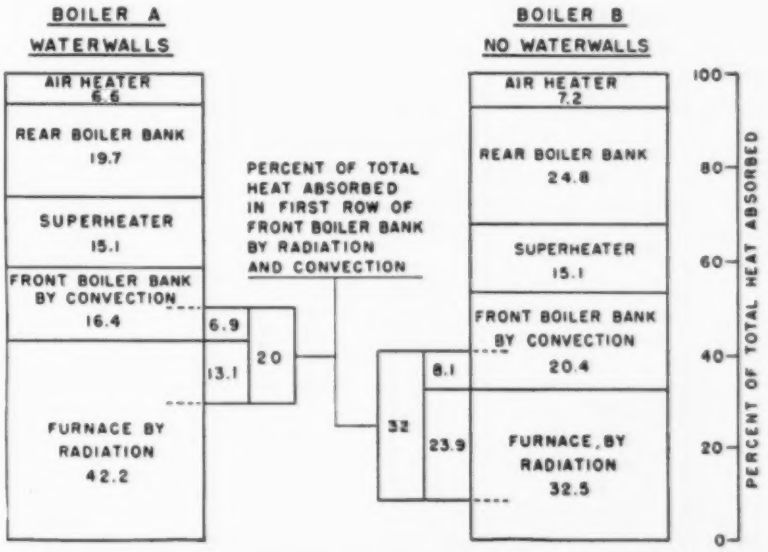
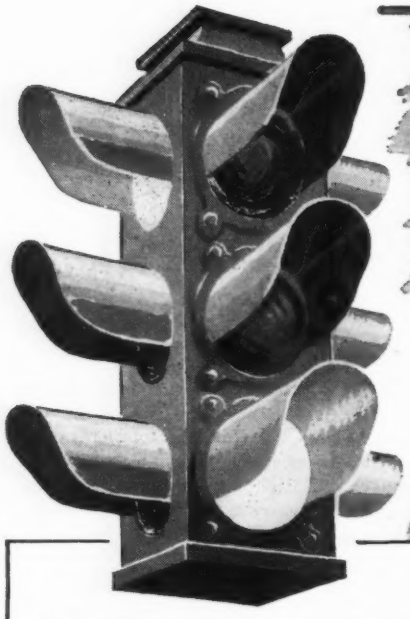


Fig. 4—Heat absorbed in component parts of boilers identified as *A* and *B* in Table 1

TABLE 1.—EFFECT OF WALL COOLING ON FURNACE TEMPERATURE

Identification	A	B	C
Boiler similar to that shown in Fig. 3	With side and rear walls cooled	No wall cooling	Same as B with width increased by 133 per cent
Release Rate			
Btu per hr per cu ft furnace volume	71,000	71,000	30,500
Btu per hr per sq ft effective projected radiant absorbing surface	162,000	378,000	162,000
Absorption rate, Btu per hr per sq ft of effective projected radiant absorbing surface	63,000	116,000	63,000
Gas temperature leaving furnace, F	2,430	2,700	2,430



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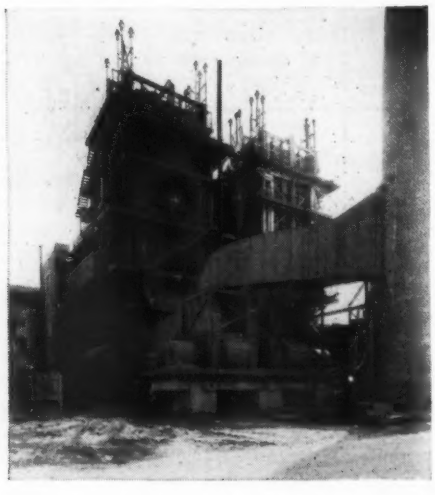

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An indication of the heat absorbed by the component parts of boilers, identified as *A* and *B* in Table 1, is shown in Fig. 4. With water walls installed, for boiler *A* 42.2 per cent of the heat is absorbed in the furnace by radiation whereas only 32.5 per cent is absorbed in the furnace by radiation in Boiler *B*. Although a greater percentage is absorbed in Boiler *A*, the rate per square foot of absorbing surface is considerably less. The first row of boiler tubes generates steam at a high rate since heat is applied by radiation and by convection. It will be noted that 20 per cent of the total heat absorbed is taken in the first row of the boiler with water-

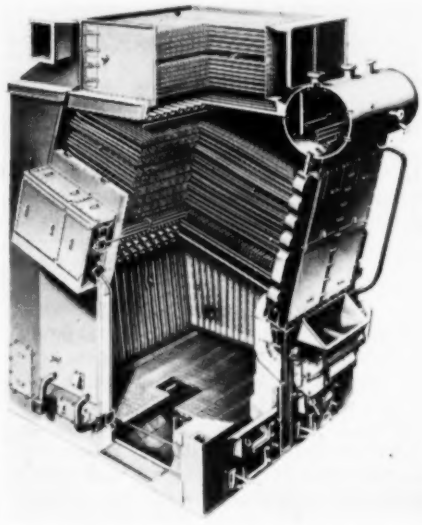

Fig. 5—Stoker-fired sectional-header boiler with water-cooled side and rear furnace walls, superheater and tubular air heater

cooled furnace walls (13.1 per cent by radiation and 6.9 per cent by convection). In the boiler without furnace wall cooling 32 per cent of the total heat absorbed is taken in the first row (23.9 per cent by radiation and 8.1 per cent by convection). Therefore, the use of water-cooled furnace walls not only reduces furnace temperature and brickwork maintenance but also reduces the rate at which steam is generated in the first row of steam generating tubes. In most marine boilers this is the critical row from the circulation standpoint.

Stoker Firing

For economical reasons coal-fired boilers have been installed generally in vessels in inland and coastal services. Since the spreader stoker provides an efficient means for burning bituminous coals of widely varying characteristics, it has been used for most coal-fired marine boilers on Lake carriers for the past ten years. Poor quality or small sized coals which are not suitable for other types of stokers can be burned with the spreader. The fines are burned in suspension, and the coarser particles on the grate.

Because of the thin fuel bed, the spreader will follow load variations very closely, approaching oil firing in this respect. Automatic control of the fuel-air ratio is essential to satisfactory operation. When the load drops off and the coal feed

and air flow are reduced by the control, there is so little coal on the grates that the steam pressure does not materially increase. Conversely, when the load is rapidly increased the coal feed and air flow are increased and the heat input to the boiler increases almost instantly.

The furnace of a stoker-fired boiler must be arranged for sufficient grate area and for adequate distance for flame travel to the relatively cold boiler generating surface. This results in a furnace considerably larger than one designed for oil fuel. To prevent slagging, ample water-cooled surface must be provided in the furnace to reduce the gas temperature below the softening temperature of the ash. A stoker-fired marine boiler which meets these furnace requirements is shown in Fig. 5.

Sectional-Header Boiler

The sectional-header boiler, typical of the type installed aboard Lake boats, has a setting height which allows an adequate distance for flame travel. Overfire jets in the rear and side walls provide turbulence, promote combustion, and help to control smoke. The vertical water-cooled walls reduce the furnace temperature and protect the refractory. The inlet headers of the water walls, located at the grate line serve as effective clinker chills which prevent the formation of slag that can disrupt the fuel bed in this area. The tubes of the screen bank between the furnace and the superheater are of larger diameter than those which make up the

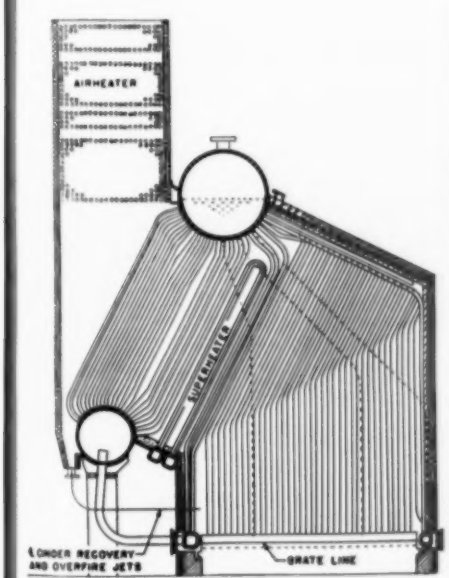

Fig. 6—Bent-tube boiler with water-cooled side and rear furnace walls, vertical superheater and tubular air heater

main boiler bank. This arrangement assures an adequate supply of water to the portion of the generating surface which absorbs the heat at the highest rate and also provides wider gas passages in this hot gas zone.

The bent-tube boiler shown in Fig. 6 is arranged for application of a vertical superheater. With this arrangement the header at the grate line which feeds the

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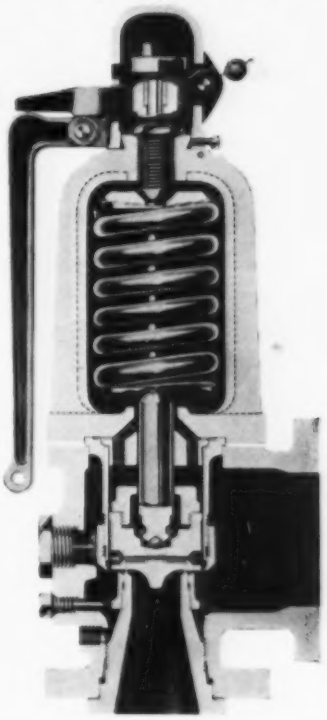

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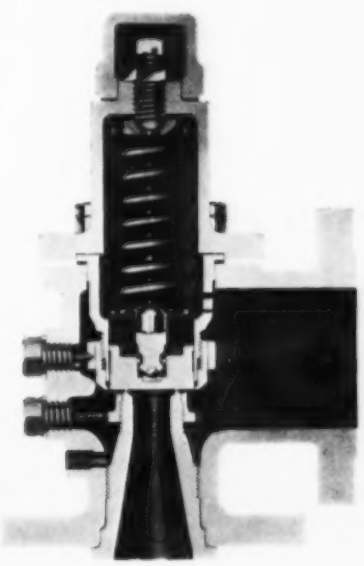

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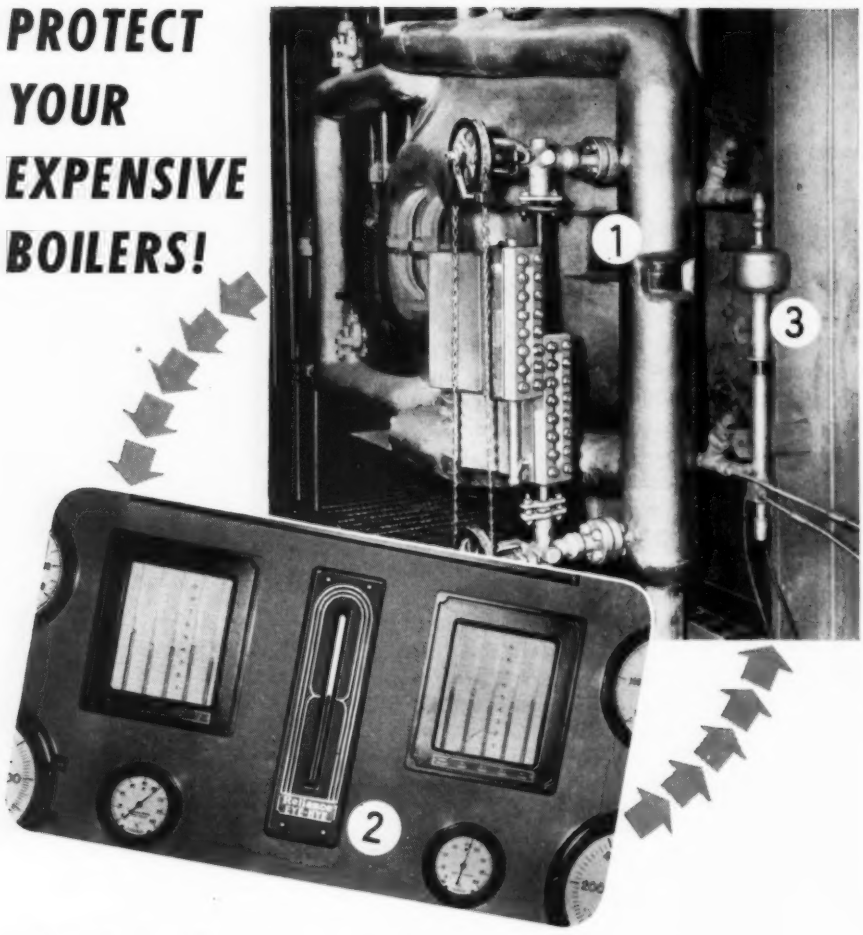

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front boiler bank is considerably below the lowest point at which the combustion gas enters the front-bank generating surface providing a reasonable distance for flame travel. Overfire jets located between tubes above the grate divert the gas flow away from the bank and increase the effective distance for flame travel. The distance for flame travel on the outboard side of the grate is ample. It is essential that combustion be complete since no further burning takes place after the gas enters the cold surface of the front boiler bank. The inlet headers serve as cinder chills at both sides and at the rear of the grate. Cinders which collect in the hopper inboard of the water drum, due to the reduction in gas velocity above the hopper, may be recovered and returned to the furnace for reburning.

Superheaters

Increased plant efficiency is achieved by increasing the operating pressure, steam temperature and feedwater temperature. As the feedwater and steam temperature are increased a greater portion of the heat absorbed by the complete boiler unit is absorbed in the superheater. As shown in Fig. 4 the heat absorption by the superheater is approximately 15 per cent of the total with steam conditions of 450 psi, 750 F. With boilers designed for the highest steam temperature in use in marine service today, 1020 F, over 26 per cent of the total heat absorbed is taken up by the superheater.

In order to have an economical temperature difference between the combustion gas passing over the superheater surface and the high temperature steam within the surface it is essential that the superheater be located in a zone of high gas temperature. This limits the amount of convection boiler surface used as a screen between the furnace and the superheater. With a steam temperature of this magnitude, 1020 F, the rest of the boiler components are in effect built around the superheater. Superheater materials must of course be satisfactory for the temperature and stress encountered and in this particular superheater four different alloy materials in addition to carbon steel were used.

Multiloop superheater elements which require fewer header joints and which improve steam distribution are used for this very high temperature superheater. This type of element is ideally suited for such application because space for installation was limited. Also since the terminal ends of the elements are seal-welded to the headers, minimizing the number of joints was of great importance. Above 900 F expanded joints tend to loosen due to relaxation effects. For this reason expanded tubes are also welded inside the header to ensure tightness. The elements are arranged in line resting on and hung from water-cooled supports. Soot blowers are installed in the center of the superheater surface positioned at right angles to the superheater elements.

An increasing number of boilers operated on the Great Lakes are oil fired. Available Bunker C oils contain impurities which when burned cause or promote the

formation of slag. This slag adheres to the pressure parts predominantly in the 2000 F to 1200 F gas temperature zone, the zone in which the superheater is located. Generally, the slag is water soluble and may be removed by water washing. Tests and investigations are being conducted to determine the causes for slag formation and methods to reduce or eliminate it.

In bent tube boilers the superheater surface may be arranged so that slag accumulation will be reduced or eliminated. With the vertical superheater arrangement the elements are in line and parallel with the boiler tubes. Soot blowers are installed at right angles to the superheater elements for most effective cleaning. Slag deposits, if they occur, may be more readily removed because of the in-line arrangement of the screen bank and the superheater surface.

Heavy, bulky supports of temperature-resistant alloy castings, which have caused maintenance difficulties in some boiler designs, are unnecessary. Most of the weight of the superheater elements is carried on the headers, water-cooled lugs on the elements being used primarily for positioning.

Since the superheater elements are installed through the furnace, header boxes and doors in the front and rear casing, for access to the elements, are not necessary. This eliminates a source of possible gas and soot leakage in the casing and greatly simplifies and strengthens the casing construction in this area.

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Four gas-turbine plants, first to be installed in the state of Connecticut, will be placed in service early in 1953 by the Connecticut Electric Light & Power Company, according to an announcement by R. H. Knowlton, president.

These units, of 20,000 kw aggregate capacity, will be built at the Schenectady Works of General Electric Company and will be used for emergency and peak-load operation, a service for which they will be well suited, because it will be possible to bring them up from standstill to full load and put them on the line in approximately fifteen minutes.

Each unit will compress the outside air in two stages with an intercooler between the compressors, each compressor being driven by a separate turbine, with the two turbines in a single casing. One turbine will operate at constant speed, driving the 5000-kw generator through reduction gears, in addition to the high-pressure compressor. The second turbine will be driven by the exhaust from the high-pressure turbine and operate at variable speed, depending on the load, thus developing higher efficiency proportionately under partial load. The exhaust from the low-pressure turbine will pass through a regenerator to heat the incoming air from the high-pressure compressor before mixing with the fuel in the combustion chamber.

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INCO Holds Corrosion Conference at Wrightsville Beach, N. C.

APPROXIMATELY eighty engineers representing naval and coast guard headquarters, shipbuilding companies, equipment manufacturers, consulting firms specializing in corrosion research, and various utility groups met at the Sixth Annual Engineers Group Meeting held at the Harbor Island Corrosion Testing Station, Wrightsville Beach, N. C., on June 6 to 8. The meeting, sponsored by International Nickel Company, was directed by **F. L. La Que,** head of the Corrosion Engineering Section of the INCO Development and Research Department.

The engineers' visit included guided tours through the Kure Beach and Harbor Island Testing Staticns where extensive research projects relative to corrosion problems in sea water and marine atmosphere are in progress. Studies of the effect of protective coatings in curbing corrosion, the effect of marine fouling, the effect of water velocity on equipment such as condenser tubes, piping, pump impellers, and under-water parts of fast moving ships, also marine atmospheres vs. corrosion problems, represent a few of the many research projects in progress at the Testing Stations.

The meeting included an informal discussion of general corrosion problems and those commonly encountered in power plants were taken up at a special session.

Condenser Fouling

Of interest to power engineers was a discussion of fouling of water intake tunnels by various organisms. **Dr. Clapp** of the W. T. Clapp Laboratories, described the mechanism of fouling and the methods utilized in keeping tunnels free from marine growths. He indicated that a continuous toxicity, about 0.25 ppm of chlorine, is necessary to prevent fouling. Continuous chlorination has proved to be cheaper and more effective than intermittent slugs of chlorine.

H. E. White, of Stone & Webster, stated that increasing the water temperature to about 104 F for a short period each month greatly reduced marine fouling. In this respect, Dr. Clapp related his observations relative to the effect of temperature alone and the combined effect of temperature and chlorination. Temperature increase has been shown to decrease marine fouling but the temperature range and suddenness of heat treatment alone does not provide lethal conditions. Tests, to date, of the combined effect of chlorination and temperature, do not indicate promising results. Mr. La Que indicated that 0.50 ppm continuous addition of chlorine would prove the most safe concentration under a high contamination of water by the organisms. Lower chlorine rates would be difficult to control in highly contaminated waters.

The effect of pH and of gases, such as oxygen, ammonia, and carbon dioxide, on the corrosion rate of iron and copper was discussed, but it was obvious that additional basic research is vitally necessary in the field of corrosion of metal surfaces in contact with boiler water.

J. D. Ristroph, Virginia Electric & Power Co., described a series of experiments being conducted by his company relating to the corrosion resistance of various alloys in contact with condensate. These tests are being conducted to determine which alloys are most resistant to attack in pre-boiler apparatus in contact with water ranging in temperature from 160 F to 400 F. Heater drips are run through 50-ft coils of twelve different alloy compositions. The results will be used to select pre-boiler apparatus for a new installation which will handle feedwater for a C-E controlled-circulation boiler now being built.

H. M. Rivers, of Hall Laboratories, discussed the various problems of corrosion encountered when iron is in contact with boiler water. The corrosion of iron by pure water, the attack on heat transfer surface by caustic in the concentrating film at the tube surface, caustic attack under adherent deposits, hydrogen damage, and corrosion fatigue were included.

E. N. Skinner, of International Nickel Co., introduced the subject of corrosion of high-temperature surfaces in contact with fuel oil ashes high in vanadium. He explained that the corrosion problem involves vanadium, sodium, and sulfur in which the attack becomes serious when a molten slag layer is in contact with the metal. The bulk of the vanadium is believed to exist as an organic compound. Centrifuging the oil does not lower the vanadium content in the oil ash. He described some of the laboratory corrosion tests performed by his company and suggested as possible remedies the use of lower vanadium oils, development of a protective layer against active attack, additives which will change the chemical composition of the ash at the metal surface, or replacing the sodium in the oil ash with calcium.

H. A. Grabowski, Combustion Engineering-Superheater, Inc., pointed out that, although vanadium pentoxide has been commonly ascribed as the agent promoting corrosion at the heated surfaces, there has been no positive identification of the phase in which vanadium exists at the metal surface. The exact mechanism of corrosion, and hence the liquid compound said to exist at the metal surface are an unknown entity. Until the exact mechanism is known, a logical procedure for the selection of metals, protective coatings or additives cannot be inaugurated.

Piling Protection

Full scale tests of marine piling started at Kure Beach have been continued at Harbor Island. Maximum corrosion of steel piling was noted in the splash zone above high tide level which determines the life of the piling; minimum attack was at the tidal zone. Tubular piling was found to be least affected by the scouring action in the surf region and was more effective than the reinforced H-section design. The determining factor in the corrosion below the surface of the water is the diffusion of oxygen and the thickness of the scale. Corrosion rates are governed by fouling characteristics and rust layer present.

Alloy steels do not show as much pitting as plain steel below the water, but they exhibit the same relative weight loss. The corrosion rate of wrought iron specimens were similar to plain steel.

Most microorganisms tend to retard corrosion of steel. Sulfate-reducing bacteria is the prime source of corrosion of piling under water. Ordinarily most microorganisms act as oxygen barriers to the piling.

Alloy steel is far superior than plain steel to corrosion in the region above the water, half-tide level. Copper in amounts of 0.01 to 0.05 per cent in open-hearth iron reduces the corrosion rate of iron about sevenfold. In comparing the corrosion resistance of carbon steels, the copper content should be included.

Protection of steel piling may be effected by a number of methods In the case of existing piling the simplest procedure is to provide cathodic protection, providing magnesium or steel anodes, increasing the current density to the piling. An increase in the velocity of water will require a higher current density to effect cathodic polarization. In this discussion polarization is described as the change in potential in respect to a calomel half cell due to a change in current to or from the material. Above the water line or high tide, cathodic protection is ineffective. Corrosion-resistant sheeting, monel or copper-nickel alloys should be used in areas above tidal zone.

Piling should be painted or coated in the mud region, a protective template should be installed at the surf region, the steel area below low tide should be protected by cathodic action using a sacrificial anode as magnesium, monel facing should be used from about 2 ft below low tide to the area above high tide, and finally the exposed area above the portion protected by monel should be painted.

In cast irons the graphitic corrosion product in some cases can form an impervious layer to corrosive activity. In general alloy irons are superior to cast irons in corrosion resistance. Composition of the iron is not the important item but the structure determines the accessibility to attack. Experience has shown that in choosing piling the buyer should specify the iron on the basis of tensile strength and allow the foundry to set up the grain structure. Where erosion is a factor high chromium content should be specified. Where corrosion is the pre-

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dominant factor the buyer should specify a high nickel (30 per cent) content.

Marine Fouling

Sulfate-reducing bacteria have been shown to promote the principal corrosion beneath the water. Tests have shown where live barnacles have been removed from the metal surface, no pitting was noted. Where dead barnacles were noted almost always a pit was in evidence. One explanation offered was that the bacteria in dying release hydrogen sulfide and thus promote pitting.

Although painting will minimize fouling for 3 to 4 years, it offers no permanent protection. Penta-chlorophenol was used at the laboratory and showed some success in reducing fouling. As a positive preventative no chemical other than chlorine is recommended. Bromine may be used but the costs are prohibitive.

The corrosion resistance of aluminum alloys is enhanced by the addition of manganese, magnesium and chromium to heat-treated alloys. Copper and tungsten are detrimental. In aluminum-cast alloys, magnesium and silicon improve their qualities and copper lowers the resistance. In general, heat treating the alloy increases the resistance to corrosion. In welding alloys the magnesium must be low to prevent intergranular segregation. **Dr. Goddard** of Aluminum Ltd. of Canada indicated that fouling did not affect the corrosion-resistant properties of aluminum. In tests at Kure Beach at low rates of flow, 1–2 fps, submerged and heavily fouled specimens were not attacked appreciably at welded, plain or riveted areas. Strength of the metal was not affected by submergence or being exposed to marine atmosphere.

Some tests were cited, relating to corrosion of aluminum in marine atmospheres. Where monel rivets were used in attaching aluminum strips in a marine atmosphere, the corrosion was not serious. Aluminum rivets are not too satisfactory due to lower tensile strength. Monel and 18–8 stainless rivets were preferred. Under water stainless steel is the preferred metal to be placed in contact with aluminum. Its galvanic action is small, hence it is superior to copper and monel.

When aluminum was left uncoated in sea water, some corrosion was noted under the organisms attached to it. Specimens coated with zinc chromate and copper-base antifouling paint were not attacked.

Condenser Corrosion, Ship Fittings Deterioration

One series of tests conducted at Harbor Island is to rotate a series of disks, at a tip velocity of 27 fps, in sea water and to compare the resistance of the various metals. The attack on the specimen appears to be incident with the loss of the protective coating of the metal. It has been observed that attack of copper alloys is most prevalent at the tip of the disk, whereas, in the steel specimen the attack is nearer the center.

From jet impingement tests it has been concluded that impingement corrosion is fully electrochemical in nature, whereas, cavitation is a purely mechanical effect where the protective film is destroyed and removed.

Status of Atomic Power

FOLLOWING are excerpts from a talk by Gordon Dean, Chairman of the U. S. Atomic Energy Commission before the New York State Chamber of Commerce, June 7, 1951:

Atomic power is not yet on the market and I, for one, am extremely hesitant to say just when it will be. There are several reasons for this. In the first place, there are technical difficulties which stand in the way of building atomic power plants at costs that will make them economical to operate. In our present state of knowledge, we could undoubtedly build an atomic power plant right now, but there is no chance in the world that it could produce power at anything approaching the relatively low cost of power produced from coal or by hydroelectric means. We will, as a matter of fact, sometime this year, put a reactor in operation at our Idaho testing station that has been designed to produce, as an experiment, something over 100 kw of power, but it will not be the kind of plant that would be needed to produce power commercially. It will be primarily a research reactor, and its main purpose will be to test the process termed "breeding," which is an attempt to operate a reactor in such a way that it will produce more fissionable material than it consumes.

Needs of National Defense Paramount

Another important reason why commerical atomic power isn't right around the corner is that the need for a new source of commercial power in this country, with its vast deposits of coal and oil and its hydroelectric systems, is not as great at the moment as some of the other needs that the products of atomic energy can help meet. By this I mean that at the present time the needs of national defense are paramount, and in this kind of a setting, it is only natural that even our quest of atomic power is directed to military channels. We are, therefore, concentrating right now on developing atomic engines for the propulsion of submarines and aircraft. We are much further along on the submarine reactor than on the aircraft one, but eventually we are going to have both. And as a special bonus we are going to pick up a lot of technical know-how that will assist immeasurably in cutting the costs of atomic power for commercial use. What we are doing, essentially, is charging a good share of the high developmental costs of power reactors to national security, and, in the process, getting at the earliest date possible a kind of propulsion unit that will reduce almost to the vanishing point the dependence of naval vessels and military aircraft upon bases of fuel supply.

Industrial Cooperation

Reactor development work has attracted the interest of private industrial groups concerned with the production of electrical power. This is a healthy development, and we intend to do everything possible, consistent with the requirements of national security, to work with these groups toward mutual objectives. In the past, for example, we have had the benefit of the wise counsel of an industrial advisory group headed by James W. Parker of the Detroit Edison Co., which submitted some very valuable recommendations to us about two years ago. At present, we are working closely with an advisory committee on cooperation between the electric power industry and the AEC, which is headed by Philip Sporn, president of the American Gas & Electric Service Corp. Mr. Sporn's committee has recently submitted to us a very thought-provoking report based upon a two-year survey of our program. We are presently giving some intensive study to this report, and expect to respond to it publicly sometime in the near future.

We are also entering into agreements with the Monsanto Chemical Co., Union Electric of Missouri, Detroit Edison Co., Dow Chemical Co., Commonwealth Edison Company, Public Service Co. of Northern Illinois, Pacific Gas and Electric Co. and the Bechtel Corp. whereby representatives of these firms, organized into four working groups, will be given an opportunity to come into our program and study the practicability of private industry building and operating reactors to produce plutonium for the Government and power for industry at the same time, thus presumably reducing the cost of both. There is a lot of merit to this idea, but I don't think the public should get the impression that these firms are going to be able to walk into our laboratories, stay about six months or so, pick up a few tricks of the trade, and then be able to go out and build economically feasible power reactors. It isn't going to be as simple as that. There is a great deal of technological, engineering and design work that needs to be done in the reactor field before atomic energy will contribute very much to the overall power supply of this country.

Far from being a producer of power today, atomic energy is actually one of the nation's largest consumers, and the balance will be on the debit side for a long time to come. It has been estimated, for example, that our power requirements by the middle of 1953 will amount to about $2^1/_2$ per cent of the total installed electric power capacity of the United States—an amount equal to around 85 per cent of the production capacity of the Consolidated Edison Co. of New York.

Oil Supply and Demand

A report on oil supply and demand for its products in 1951 has just been issued by the Oil Industry Information Committee of the American Petroleum Institute. Following is a digest of the findings:

1. While military need for oil products is more than double that of a year ago, it still is only about 5 per cent of the total oil demand in this country.

2. Civilian demand for petroleum products, on the other hand, has been mounting at an unprecedented rate.

3. In 1950 civilian and military uses combined caused an increase in U. S. domestic demand for oil products of almost 12 per cent over 1949. This year the combined demand is expected to rise another 8 to 10 per cent over 1950.

4. This two-year increase of over 20 per cent, representing around 1,300,000 bbl per day, is equivalent to the total consumption of all the Western European nations.

If the expected increase in demand materializes, a tremendous expansion will be needed, involving new capital, steel and other materials in great quantities, as well as added manpower. For capital investment alone, some oil economists figure as much as $5000 per barrel-per-day, as the present-day cost of such capacity, including all production operations and delivery to consumers. Thus to expand facilities in full proportion to projected demands, the oil industry would be called upon to expand about three billion dollars this year in addition to its current large costs for capital replacement.

In the five years between V-J Day and the summer of 1950 the oil industry, by spending more than ten billion dollars, built up a fairly comfortable margin of extra capacity ahead of demand. In other words, during these years the industry increased its crude oil reserves some 24 per cent and its refining capacity by 26 per cent.

How fast the demand situation changed is illustrated by U. S. Bureau of Mines forecasts. At the beginning of 1950, the Bureau estimated that the domestic demand for the year would exceed that of 1949 by $4^1/_2$ per cent. However, by May 31, 1950, even before the Korean situation had affected the demand, the Bureau raised its forecast to 7.1 per cent; but the final result was 12 per cent.

Fortunately, the oil industry had sufficient capacity to meet this sudden increase—principally from existing oil wells and from reserves in its refining and transportation facilities.

This year and last, the rate of daily consumption has been increasing three times as fast as the yearly average from 1941 through 1949. But greater than the increases in annual volume of oil produced have been the increases in the amount of oil found and developed; that is, despite the vast withdrawals, proved reserves have increased nearly every year. Included in the oil industry's present capacity and facilities are the following items:

Proved reserves (underground)—29.5 billion barrels
Producing oil wells—468,000
Daily production of liquid hydrocarbons 6,675,000 bbl
Daily productive capacity—7,275,000 bbl
Daily imports—950,000 bbl
Daily exports—280,000 bbl
Crude and product pipe lines—153,000 miles
Refineries—367
Refining capacity (daily)—6,900,000 bbl
Railroad tank cars—about 100,000
Seagoing tankers—500
Barges—2400
Service stations—200,000 (approx.)

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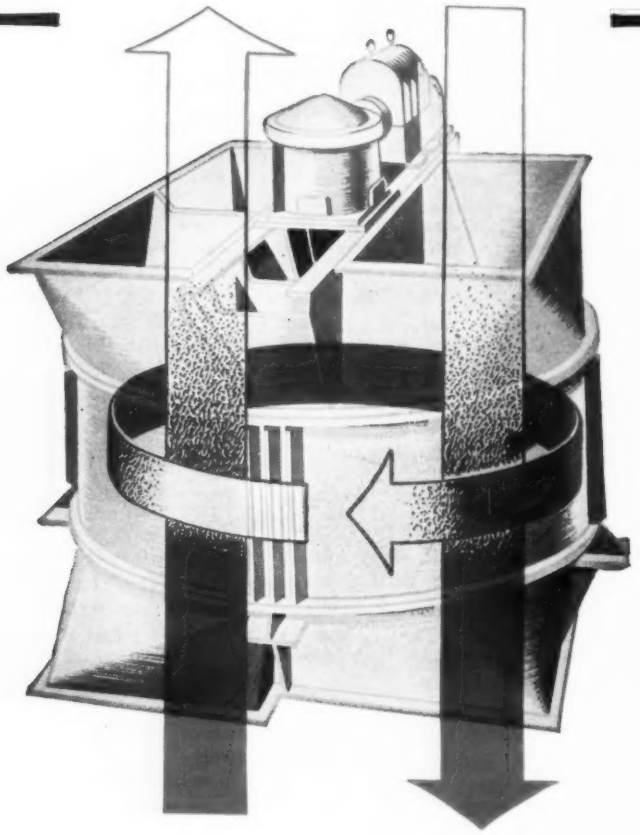

Here indeed is impressive evidence of the wide acceptance of the Ljungstrom air preheater. Since the war the total capacity of steam generating units equipped with Ljungstrom air preheaters, installed, under construction or on order in industrial and utility plants throughout the country comes to well over 200,000,000 lbs of steam per hr.

The reasons for the steadily increasing preference for the Ljungstrom air preheater are simple enough. The continuous regenerative counterflow principle assures maximum heat transfer with minimum weight and size. Flexible and compact, it may be used in a wide range of applications. Its proven reliability and low maintenance eliminate costly shutdowns.

If you are planning to build a new plant or modernize an old one, investigate the possibilities of the Ljungstrom. The specialized experience of Air Preheater engineers is at your disposal, to aid in effecting the most economic heat recovery from flue gases.

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John M. Hopwood Dies

John M. Hopwood, of Pittsburgh, chairman of the board of the Hagan Corporation and its subsidiaries, died on June 8 at Vero Beach, Fla., following a lengthy illness. He was 67.

Coming to this country from Wales at the age of 21, he became associated with mechanical and electrical equipment in the collieries of Kentucky and Western Pennsylvania and later joined the West Penn Traction Co. where he first met up

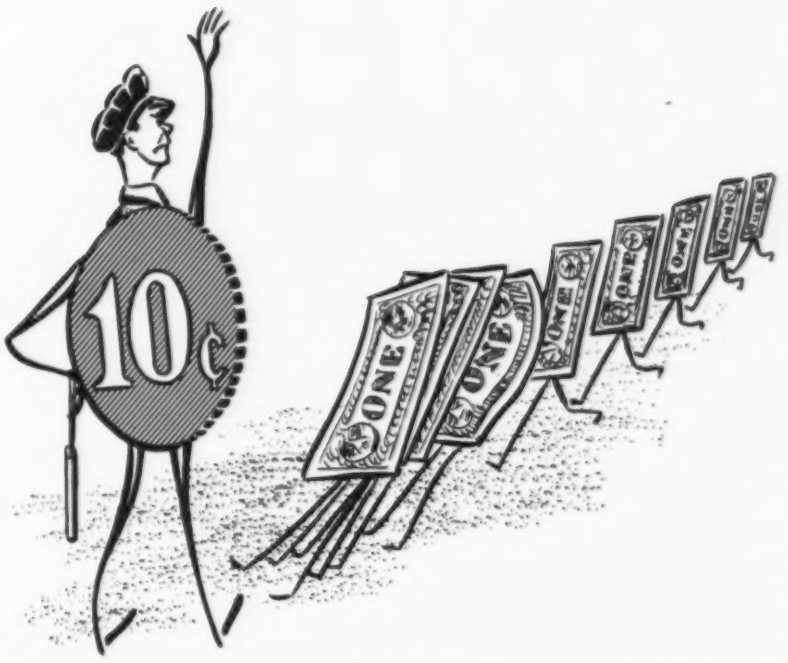
with mechanical stokers. His interest in this equipment led to a connection with the stoker manufacturer as sales representative for a time in the Pittsburgh territory.

This association and the opportunity it afforded to observe the operation of boilers led to an active interest both in developing an automatic combustion control and the combating of scale and corrosion in boilers. In association with George Hagan and T. A. Peebles he formed the Hagan Corporation in 1918 to market the Hagan control and other devices and a few years later, following an extensive cooperative research program conducted by Dr. R. E. Hall at the U. S. Bureau of Mines, he set up Hall Laboratories, Inc., as a subsidiary of the Hagan Corporation, and as consultants on water-conditioning problems. Calgon Inc. and the Buromin Company were two other subsidiaries set up to market the chemicals.

Retiring in 1948 as President, Mr. Hopwood became chairman of the board, and was a moving spirit in the expansion of Pittsburgh's Shadyside Hospital. He was also a trustee of Bucknell University and a director of the Colonial Trust Co.

A. G. Christie Honored

At the Johns Hopkins Commencement on June 12, Professor A. G. Christie was accorded the highest academic honor of the University—Doctor of Laws—in recognition of "leadership in engineering education and in the engineering profession."



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NEW CATALOGS AND BULLETINS

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 18, N. Y.

Boiler Feed Pumps

De Laval Steam Turbine Co. has issued a 12-page bulletin on high-pressure barrel-type boiler feed pumps. In addition to a two-page cutaway cross-section there are photographs of many component parts and explanations of automatic thrust balance and the manner in which double volutes eliminate radial load. An interesting illustration shows how the inner assembly of the pumping unit may be removed with the aid of an "A" frame.

Chemical Cleaning

An attractive 8-page booklet, "Dowell Service in Industry," has been made available by Dowell Incorporated. Illustrations show how the cleaning service may be used for condensers, water mains and steam generating units. There is also a series of brief case histories.

Combustion Meters

Bulletin 51-553 prepared by The Hays Corp. describes the Hays Combustion Meter (CO_2 recorder) which operates on the Orsat principle of volumetric measurement and chemical absorption. Methods of installation and sampling and models available are discussed.

Direct-Flow Pump

A two-color, six-page bulletin illustrates and presents features of design, construction, dimension drawings and performance data of the recently developed 3-in. stroke Direct-Flow Triplex Pump manufactured by The Aldrich Pump Co. Applications for this type of pump include chemical handling, hydraulic systems and oil-field service.

Piping Fabrication and Erection

Piping services for steel mills, gas transmission systems, central stations, municipal water plants and general industrial applications are described and illustrated in a 24-page brochure released by the Piping Department of the Machinery Division of Dravo Corporation. In addition to photographs of typical installations, facilities for designing and fabricating pipe are illustrated.

Pipe Supports

Two catalogs covering variable-support pipe hangers and non-resonant sway braces have recently been made available by the Bergen Genspring Corp. Catalog No. 501, 12 pages, shows typical uses and representative dimensions of variable-support hangers having rated loads from 80 to 5148 lb. Catalog No. 502, eight pages, describes non-resonant variable-support-hangers and non-resonant sway braces. Both catalogs include load-deflection charts.

Refractory and Insulating Materials

A series of bulletins on castable cements, bonding cements for air and heat setting, ramming-type refractories, insulating blocks and blankets, plastic-heat insulations, fill and electrical insulations, and surface protective coatings has been collected together in a flexible cover by the Refractory & Insulation Corp. The bulletins show where, when and how to use these materials in various types of heat-generating equipment.

Roller Bearings

Shafer Bearing Corp. has released Catalog No. 51 which illustrates and describes the full line of Shafer industrial-roller-bearing products including pillow blocks, flange units, flange cartridge units, cartridge units, duplex units, take-up units and take-up and frame units. A section of the 56-page catalog is devoted to engineering and load-rating data, and many product applications are illustrated.

Tramp-Iron Removal

The Eriez Manufacturing Co. has issued a 16-page catalog on "Non-Electric Permanent Magnetic Separators for Tramp Iron Removal." Complete descriptions of separators and pertinent engineering data including photographs, drawings and tabular specifications are given. Also dealt with are information on the selection of appropriate magnetic separators.

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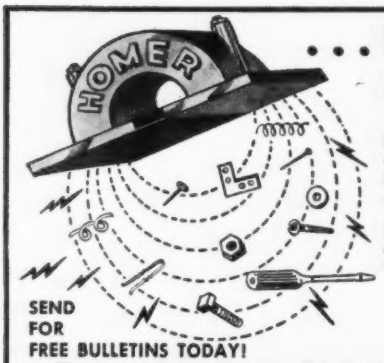

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